Municipal Council of Maputo
Republic of Mozambique

Comprehensive Urban Transport Master Plan for the Greater Maputo

Final Report

Volume 1

Master Plan Report

March 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

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Abbreviations

AfDB	African Development Bank
ANE	*Administração Nacional de Estradas* (National Roads Administration)
ATROMAP	*Associação dos Transportadores de Maputo* (Maputo Association of Transport Operators)
BADEA	*La Banque Arabe pour le Développment Economique en Afrique* (Arab Bank for Economic Development in Africa)
BMS	Bridge Management System
BOT	Build, Operate and Transfer
BRT	Bus Rapid Transit
B-Zone	This zoning level is adequate to examine the arterial traffic network. B-zones were set using the "bairro", the smallest unit used for the population census data. Some areas of the suburbs were zoned in a way that consolidated a few bairros. The number of B-Zones within the study area was 40.
CBD	Central Business District
CCO	Control Centre for Operations
CFM	*Caminhos de Ferro de Moçambique* (Mozambique Ports and Railways Company)
CMM	*Conselho Municipal de Maputo* (Maputo Municipal Council)
CTA	*Confederação das Associações Económicas* (Confederation of Economic Associations of Mozambique)
C-Zone	This zoning level divided the urban center into smaller sections to assess the detailed forecast and planning. Bairros were broken down into smaller sections to accommodate the road network in the city center. The number of C-Zones within the study area was 170.
DCF	Discounted Cash Flow Analysis
DFID	UK Department for International Development
DfT	UK Department for Transport
DMTT	*Direcção Municipal de Transportes e Transito* (Directorate of Transport and Traffic)
EC	European Commission
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EU	European Union

F/S	Feasibility Study
FEMATRO	*Federação Moçambicana das Associações dos Transportadores Rodoviários* (Federation of Road Transport Associations)
GDP	Gross Domestic Product
GIS	Geographic Information System
GMMTA	Greater Maputo Metropolitan Transport Agency
GPRS	General Packet Radio Service
HDM	Highway Design and Management
HIS	Household Interview Survey
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IEE	Initial Environmental Examination
IMF	International Monetary Fund
INATTER	*Instituto Nacional dos Transportes Terrestres* (National Institute of Land Transport)
INAV	*Instituto Nacional de Viação* (National Traffic Institute)
INE	*Instituto Nacional de Estatística* (National Institute of Statistics)
IRI	International Roughness Index
IRMS	Integrated Road Management System
JICA	Japan International Cooperation Agency
kph	Kilometers per hour
LRT	Light Rail Transit
M/P, MP	Master Plan
MCC	Millennium Challenge Cooperation
MICOA	*Ministério para a Coordenação da Acção Ambiental* (Ministry of Coordination of Environmental Affairs)
MT	Metical
MTC	*Ministério dos Transportes e Comunicações* (Ministry of Transport and Communications)
NPV	Net Present Value

OD	Origin and Destination
ODA	Official Development Assistance
PCU	Passenger Car Unit
PEUCM	*Plano de Estrutura Urbana da Cidade da Matola* (Urban Structure Planning of City of Matola)
PEUMM	*Plano de Estrutura Urbana do Municipio de Maputo* (Urban Structure Planning of City of Maputo)
PPP	Public Private Partnership
PRISE	*Programa Integrado do Sector de Estradas* (Integrated Road Sector Program)
ProMaputo	*Programa de Desenvolvimento Municipal de Maputo* (Maputo Municipality Development Programme)
PRSP	Poverty Reduction Strategy Paper
RMM	*Região Metropolitana de Maputo*
SADC	Southern African Development Community
SC	Steering Committee
SEA	Strategic Environmental Assessment
SP	Stated Preference
TDM	Traffic Demand Management
TOD	Transit-Oriented Development
TOR	Terms of Reference
TPM	*Transportes Públicos de Maputo* (Maputo Bus Company)
TRAC	Trans African Concessions
UEM	*Universidade Eduardo Mondlane* (Edurado Mondlane University)
UNICOTRAM	*União das Cooperativas de Transportes da Matola, Matola Urbano* (Union of Transports Associations of Matola)
USAID	United States Agency for International Development
VCR	Volume-Capacity Ratio
VOC	Vehicle Operating Costs
VOT	Value of Time
WB	World Bank

Chapter 1 Introduction

1.1 Background

The capital of Mozambique, Maputo, has a population of approximately 1.2 million people (2009) and is the political and industrial center of the country. It is also the entrance of the Maputo Corridor which is the busiest trunk road within the Southern African Development Community (SADC). In recent years, residential and industrial development has spread to Maputo's neighboring city and district of Matola, Boane and Marracuene creating a Greater Maputo metropolitan area of approximately 2.3 million people (2009 estimate). Urban and economic development has brought about more movement of passengers and goods; as a result the traffic conditions in this area by buses and private vehicles are getting worse.

In 2001, the Japan International Cooperation Agency (JICA) conducted the "Maputo City Road Development Study", and formulated a road improvement plan with the target year of 2020. With this plan in hand, Maputo City has improved urban roads and implemented traffic management measures including addition of traffic lights. However, due to the rapid expansion of the metropolitan area, there is an urgent need for a comprehensive urban transport development plan for areas including surrounding cities and district around Maputo.

The Government of Mozambique had adopted ProMaputo, the development program for Maputo, which serves as an "Urban Plan" for Maputo and Matola. They have also adopted a land use plan and infrastructure development policy. In addition, they also have aspirations for a Bus Rapid Transit (BRT) system for Maputo, and a Light Railway Transit (LRT) system that connects Maputo and Matola. However, there has not been any progress to deliver these plans due to a lack of financial support and a concrete, long-term vision for urban transport, thereby making it difficult to make investment decisions.

Under these circumstances, the Government of Mozambique requested the Government of Japan for assistance in formulating a "Project for the Comprehensive Urban Transport Master Plan for the Greater Maputo". This examines the expanding Greater Maputo urban area and includes formulating a comprehensive transport master plan to address the lack of policy and plans for a public transport network and road improvements, and subsequently include the pre-feasibility study for priority projects that are identified in the master plan.

This project has produced a new comprehensive urban transport master plan for Greater Maputo with the target year of 2035, as well as creating an implementation plan for high-priority projects, and providing a benchmark and guidance to the rest of the country.

1.2 Objectives

Objectives of the Study

The key objective of the study is to create a comprehensive urban transport master plan for Greater Maputo for 2035, and conduct a pre-feasibility study (Pre-F/S) for the priority projects. In addition, the study will ensure the effective use of the study outputs and facilitate the implementation of urban transport plans, and will also provide suggestions to strengthen the implementation structure and support capacity development of the agencies involved in urban transport.

Expected Outcomes

This project has achieved the following outcomes:

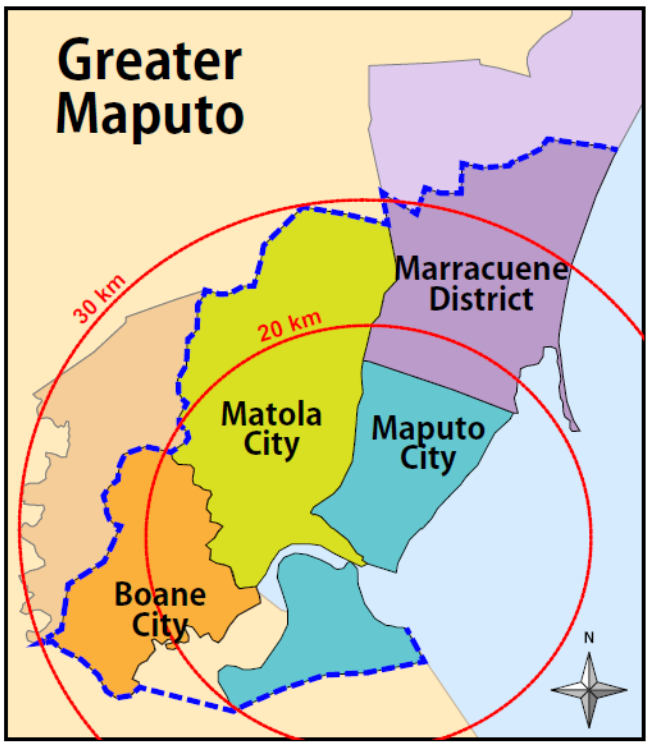
(1) Formulation of a comprehensive urban transport master plan for Greater Maputo for 2035
(2) Implementation of a Pre-F/S for project(s) selected among the priority projects proposed in the study
(3) Creation of an implementation structure and capacity-building plan for the advancement of the master plan
(4) Capacity-building of Mozambique government agencies

1.3 Study Area

The study area examined is "Greater Maputo", which was discussed and agreed at the Steering Committee meeting held on 22 February 2012 as shown in Figure 1.1. The area defined as "Greater Maputo" includes the following:

a. Maputo City except for Inhaca Island
b. Matola City
c. the southern area of Marracuene District
d. the Eastern area of Boane City, including Mozal and Boane

The areas above have strong economic linkages. Central Maputo has offices and commercial buildings, and in Matola, there are the manufacturing industries. Maputo and Matola as well as surrounding areas absorb most of the labour force. As well, there are universities, vocational schools, and secondary schools concentrated in Maputo, thus many students also commute in. With such commuting patterns, the urban transport Master Plan needed to consider the abovementioned areas as one metropolitan entity. After obtaining data on administrative boundaries at the bairros level, the study area refined based on statistical data and rationale and was defined as shown in Figure 1.1.



Source: JICA Project Team

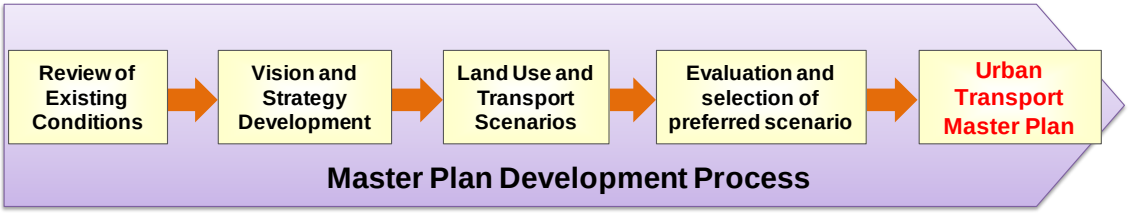
Figure 1.1: Study Area – Greater Maputo

1.4 Tasks

In order to achieve the objectives, the study carried out the following tasks:

Task	Description
Task 1:	Project Preparation and Presentation of Inception Report to Counterparts
Task 2:	Planning and Implementation of Technology Transfer
Task 3:	Collect Relevant Information (including examination of existing urban transport conditions and understanding of current issues)
Task 4:	Planning of Traffic Survey
Task 5:	Preparation and Discussion on Progress Report
Task 6:	Implementation of Traffic Survey
Task 7:	Implementation of Counterpart Training
Task 8:	Traffic Demand Forecasting
Task 9:	Setting Urban Development Scenarios
Task 10:	Formulation of Urban Transport Master Plan
Task 11:	Develop Project Plans based on Master Plan and Create Short-Term Action Plan
Task 12:	Preparation and Discussion on Interim Report, Implementation of Third Workshop
Task 13:	Implementation of Pre-F/S
Task 14:	Conclusion and Recommendations
Task 15:	Preparation, Presentation, and Discussion on Draft Final Report
Task 16:	Implementation of Seminar
Task 17:	Preparation of Final Report

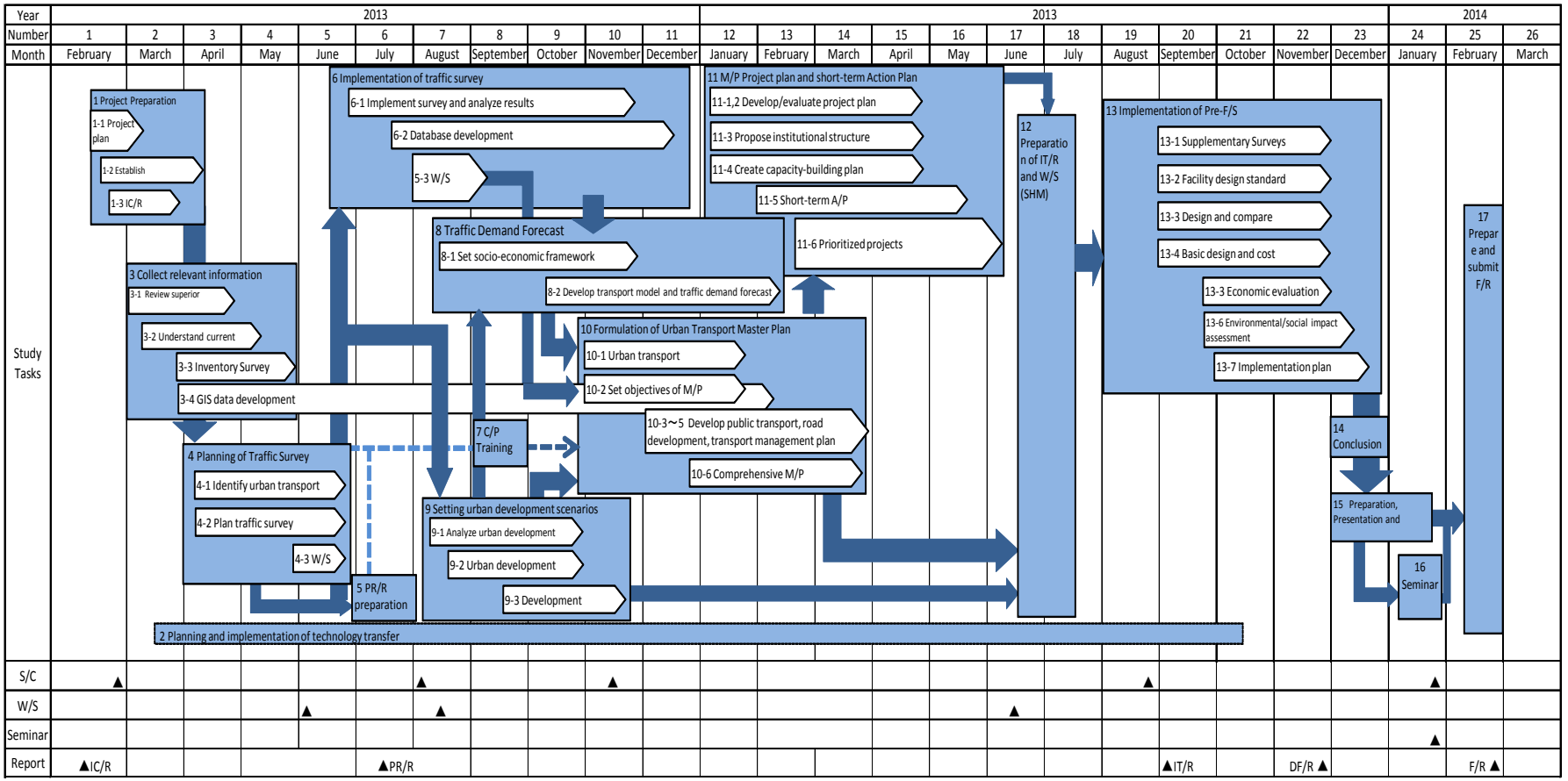
Figure 1.2 summarizes the process undertaken to develop the Comprehensive Urban Transport Master Plan for Greater Maputo. This process consisted of the work carried out under Tasks 1 through 12 in the above task list. As part of the Master Plan, priority projects were proposed, of which particularly important project(s) were selected for a prefeasibility study. The prefeasibility study was conducted toward the end of the study.



Source: JICA Project Team

Figure 1.2: Master Plan Development Process

Figure 1.3 shows the study flow from the start to the end of the study, describing the study tasks and sub-tasks.



Note : C/P - Counterpart, W/S - Workshop, M/P - Master Plan, A/P - Action Plan

IC/R: Inception Report, PR/R: Progress report, ITR: Interim Report, DF/R: Draft Final Report, F/R: Final Report

Source: JICA Project Team

Figure 1.3: Study Flow

1.5 Relevant Plans

During the implementation of this study, relevant plans, programs and projects were reviewed and taken into account in developing the Urban Transport Master Plan for Greater Maputo. Those that are directly related to this study include, but are not limited to, the following:

- Urban Structure Plan for Maputo Municipality (PEUMM) 2008
- Urban Structure Plan for Matola City (PEUCM) 2010
- Maputo Municipal Development Program (ProMaputo), a 10-year municipal development program, funded by the World Bank
- Five-Year Program of Maputo City Council 2009–2013
- JICA, Study on the Master Plan for the Road Development of Maputo, 2001
- Externally funded major transport projects such as the Ring Road Project, the Coastal Road Protection Project, the Ka Tembe Bridge Project, etc.

The results of the review as explained above, identifying issues and present conditions of transport in Greater Maputo, conducting additional surveys and analysis of existing data as well as traffic study, were incorporated into the final output of the Urban Transport Master Plan for Greater Maputo. The results of the Master Plan study in return will influence updating above mentioned plans and programs and the ongoing plans and projects such as land use plan for Boane and Marracuene and BRT project financed by Brazilian Government. The Master Plan also is taken as a base for the commuting railway implementation financed by Chinese Government and other infrastructure plans to be financed by various donors including Japanese Government.

1.6 Structure of This Report

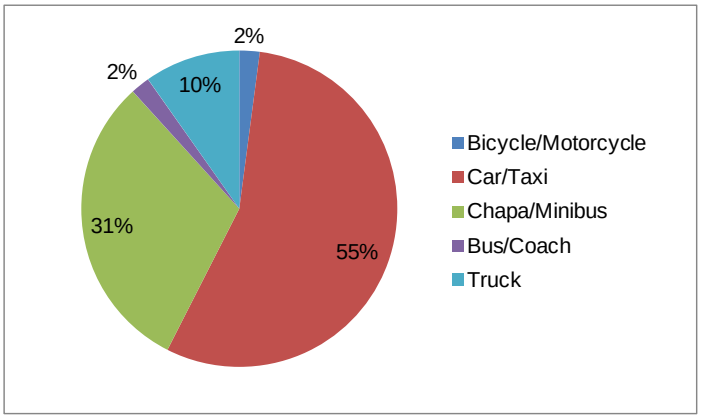
This Final Report is made up of Volume 1: Master Plan Report, Volume 2: Pre-Feasibility Study Report, and Volume 3: Technical Reports.

Chapter 2 Existing Urban Transport Issues

2.1 Overview of Existing Urban Transport Systems

In Greater Maputo, as other metropolitan areas in developing economies, rapid economic growth, a lack of quality public transport and the availability of second-hand/low-cost cars have all led to a rapid traffic growth and the associated problems of congestion, accidents, parking and environmental issues. According to the Directorate of Municipal Transport and Traffic (DMTT), congestion has led to a drop in the operating speeds of public transport including both buses and *chapa*. This not only penalizes passengers, but effectively lowers the overall capacity of the public transport system.

Cars and *chapas* dominate the traffic in Greater Maputo. For example, the sum of screenline traffic counts carried out in this study (described in Section 2.2 for more details) indicates that cars/taxis account for 55% of all vehicles, and *chapas*/minibuses for 31%, with a combined total for these vehicles being 86%, as shown in Figure 2.1. On the other hand, buses/coaches account for only 2% of all vehicles.



Note: Based on traffic counts at the screenline locations conducted in this study.
Source: JICA Project Team

Figure 2.1: Total Screenline Traffic Counts by Vehicle Type

Existing conditions of the urban transport systems in Greater Maputo are described in the following subsections.

2.1.1 Existing Road Transport System

The road network in Mozambique is classified into national roads, regional roads, municipal roads, and district roads. The national roads (e.g., N1 and N2) and regional roads (e.g., R200, R403 and R807) are managed by the National Road Administration (Administração Nacional de Estradas, ANE). Part of the national road network has been developed by the private sector, including Trans African Concessions (TRAC), which is a private consortium that built and manages the operation of the N4 Toll Road linking Mozambique with South Africa. The national and regional road networks of Mozambique, with an estimated total length of 37,000 km with 1,600 km in Maputo Province, are developed and maintained by ANE.

Furthermore, each municipal (or district) infrastructure department manages the rural and urban road networks in its jurisdiction with the primary goal of maintaining road conditions. The overall road lengths in each municipality/district are as follows: Maputo Municipality, 1,000 km; Matola Municipality, 580 km; Marracuene District, 240 km; and Boane Municipality,

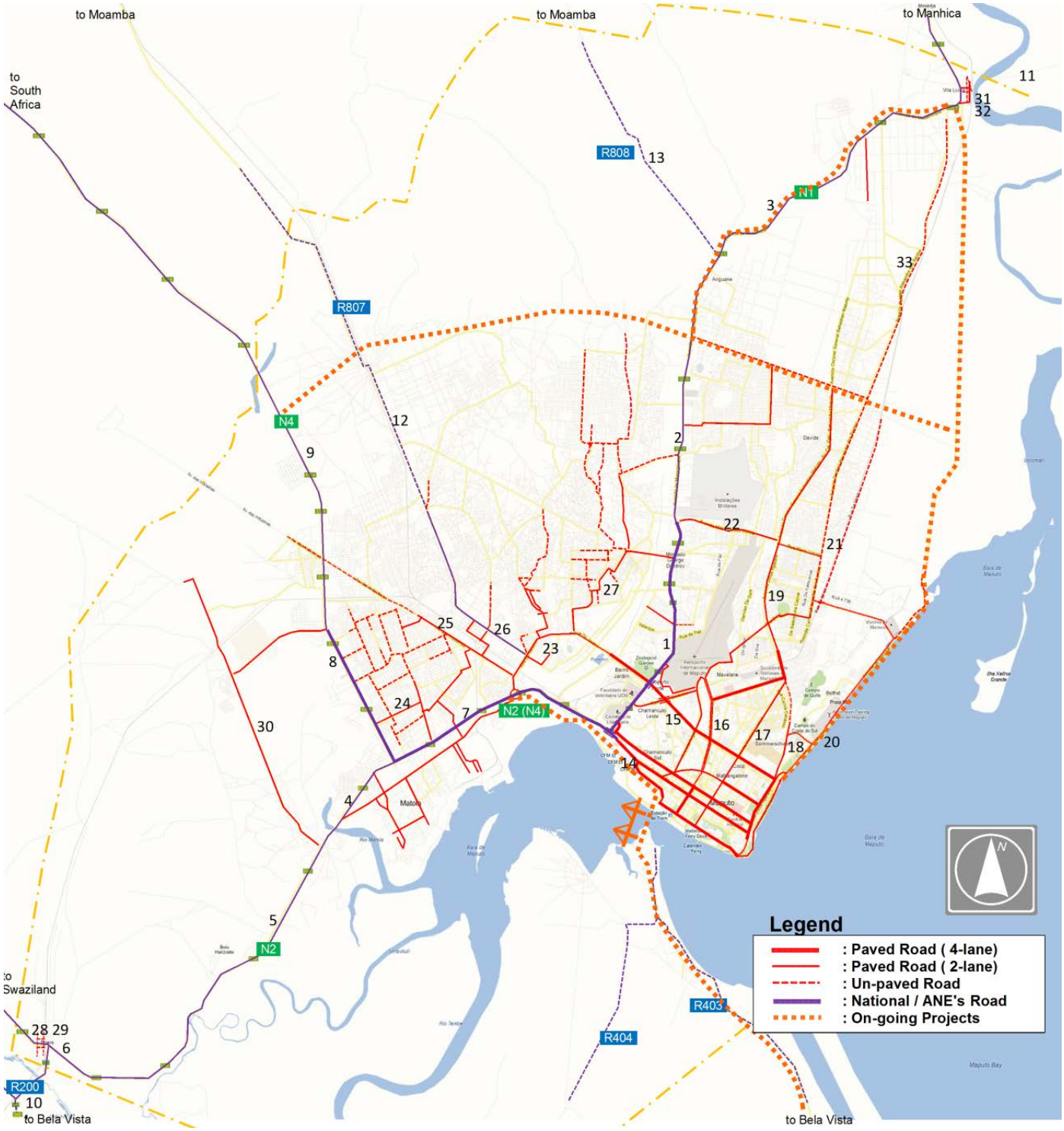
190 km. Although there are road-related divisions, the number of engineers is insufficient, which hinders the ability of these divisions from being fully operational. Table 2.1 summarizes road sector administration in Greater Maputo.

Table 2.1: Road Sector Administration

Administration	Description
National Road Administration (ANE)	ANE manages about 37,000 km of national and regional roads in Mozambique. In Greater Maputo, ANE manages the N1, N2, R200, R403, R807, etc. including unpaved road sections.
Maputo, Matola, and Boane Municipal Infrastructure Departments	At the municipal level, these departments have jurisdiction over the rural and urban road networks within each municipality.
Marracuene Infrastructure Department	This department has jurisdiction over the road networks at the district level.
Trans-Africa Concessions (TRAC)	TRAC manages and maintains about 600 km of the N4 toll road, which connects Maputo with South Africa.
Maputo Sul (Empresa de Desenvolvimento de Maputo Sul, E.P.)	Maputo Sul manages projects that include the construction of KaTembe Bridge and the Ring Road.

Source: JICA Project Team

Figure 2.2 outlines the Greater Maputo arterial road network including paved and unpaved links and national road connections. It also highlights major ongoing road projects including, for example, the Ring Road Project – a planned four-lane arterial road to serve as a bypass of the urban area connecting the existing N1 and N4 roads, and the Katembe Bridge Project, which crosses Maputo Bay, connecting the urban area of Maputo and Katembe. In addition, Table 2.2 presents the existing conditions of road network in Greater Maputo including the national and regional roads managed by ANE, and major municipal or district roads in Maputo, Matola, Boane, and Marracuene. The location of each road listed in Table 2.2 is indicated in Figure 2.2.



Note: The numbers in the map correspond to the road numbers used in Table 2.2.
Source: JICA Project Team

Figure 2.2: Existing Arterial Road Network and Ongoing Road Projects in Greater Maputo

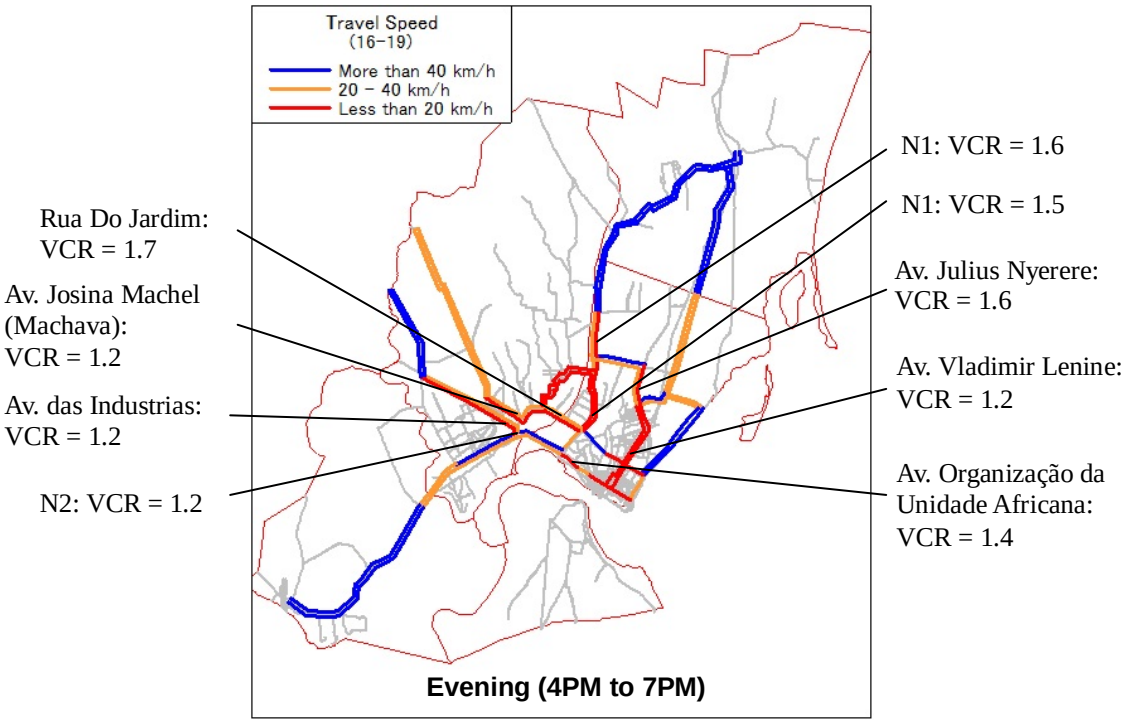
Table 2.2: Existing Conditions of Arterial Road Network in Greater Maputo

No.	Route, Location	Total No. of Lanes	Pave-ment	Summary Description
National and Regional Roads (managed by ANE)				
1	N1, Airport west side	4	Paved	Dual lane carriageway with footpath on both sides and median. Paved road surface is good and the carriageway marking is also indicated.
2	N1, Installations Military west side	2	Paved	Single lane carriageway without footpath on the north side of Av. Maria Lurdes Mutola. However, it does have a marginal width on each side.
3	N1, Anguane–Marracuene	2	Paved	N1 in the suburban is connecting to Marracuene. Single lane carriageway, with paved surface and a wide shoulder. In the curved section, it has a comfortable road designed with superelevation.
4	N2, Matola River	2	Paved	Single lane carriageway without footpaths in the west of N4 intersection. On the bridge section, there is a sidewalk.
5	N2, Matola River–Boane	2	Paved	The road surface condition is good and relatively well maintained. In some sections, drainage facilities have been constructed.
6	N2, Boane	2	Paved	In the Boane central area, the road is crowded with stores on both road sides, and many *chapa* are parked at the road side which both cause obstructions and safety issues.
7	N4, Machava	4	Paved	N4 lies between Matola-Sede of Maputo and is a dual lane carriageway. It has a limited access road with a continuous median.
8	N4, Matola Sede	4	Paved	In between the intersection of N2 to Mozal, the road is dual carriageway with wide median and shoulder.
9	N4, Jamo	2	Paved	In the north of Mozal, the N4 has a paved dual carriageway with wide shoulder
10	R200, Boane	1.5	Paved, unpaved	Secondary road which connects Boane and Bela Vista, and has a paved road section near Boane. However, passing through the road is difficult due to the collapse of a bridge crossing Umbulzi River in January 2012.
11	R804, Bairro Triunfo	1.5	Unpaved	The local road in the beach side connects Marracuene from Maputo. The unpaved road surface condition is poor.
12	R807, Cobe	2	Paved, unpaved	It is a local road which is parallel to N4. It has paved road between Bunhiçã and Machava; however, the northern side is unpaved.
13	R808, Mali	2	Unpaved	It is the local road which connects Anguane of southern Marracuene to Moamba. The surface is unpaved.
Maputo Municipal Roads				
14	Av. 24 de Juho	4	Paved	Four-lane road running east-west in the Maputo Central Urban Area in the extension of N4. It has large traffic volumes and on-street parking.
15	Av. Joaquim Chissano	4	Paved	Four-lane road running east-west connecting Matola Machava and Maputo Central Urban Area. Drainage canal separates the two carriageways.
16	Avenida Acordos de Lusaka	4	Paved	Arterial road connecting the airport and the central urban area in Maputo. It is a four-lane road with a median and the condition of road surface is good.
17	Avenida Vladimir Lenine	2	Paved	Two-lane road stretching northwards from Maputo Central Urban Area. It has some roadside stores and many pedestrians, with its width not deemed to be adequate.
18	Av. Julius Nyerere (Southern)	2–4	Paved	Two-lane arterial road connecting Maputo Urban Area and the northern region. Part of this road section does have four lanes with a median and railway crossing via an overpass.
19	Av. Julius Nyerere (Northern)	2	Paved	Two-lane road with a wide width. In some parts the road surface is paved and in good condition.

No.	Route, Location	Total No. of Lanes	Pave-ment	Summary Description
20	Av. da Marginal	2	Paved	It is the seacoast road of the Maputo eastern side. Although the road surface is paved, it has plenty of potholes. Part of the section has been damaged due to the collapse of coastal revetment.
21	Rua da Igreja	2	Unpaved	Stretching along the railway line from the northern area of Maputo urban area. Although it is an arterial road, it is unpaved with low traffic volume.
22	Av. Maria Lurdes Mutola	2	Paved	The east-west road which connects Av. Julius Nyerere and N1 on the north side of the airport. It is a paved single carriageway road.
Matola Municipal Roads				
23	Avenida Eduardo Mondlane	2	Paved	'Mini ring road' in southern Matola which connects the Maputo Urban Area and N2. It is heavily congested in front of signalized intersection with large traffic volume.
24	Matola Sede Avenida 5 de Evereiro	2	Paved	Located in the residential area of Matola Sede, the link is well developed with good pavement condition of the arterial section.
25	Matola Sede Avenida das Indústrias	2	Paved Earth	Connects Machava to the northeast. It has unpaved surfacing in its northern section and paved surfacing in the south of Machava.
26	Machava Avenida Josina Machel	2	Paved	Paved road in central Machava. There are also many large-sized vehicles parked along the roadside probably owned by some factories located in the area.
27	Infulene Avenida 4 de Outubro	2	Paved	Arterial road passing through central Infulene. Since this route frequently suffers from cracks and damage, it does not office drivers a smooth journey
Boane Municipal Roads				
28	Boane	1.5	Unpaved	Located in the central part of Boane District, there is a lot of activity along the roadside including some stores/sellers. The road is unpaved and width is also narrow.
29	Boane	2	Unpaved	Although this link is not paved, it has a wide width. Many *Chapa* stop along the section.
30	Mozal	2	Paved	The route which connects the Mozal Industrial Park with N2. It is paved and the condition of the road surface is also good. Also, its width has a margin.
Marracuene District Roads				
31	Vila Luisa	2	Paved, unpaved	The road of Vila Luisa in central Marracuene is paved in some section only.
32	Vila Luisa	2	Paved, unpaved	In the Vila Luisa central area there is a lot of pedestrian activity. The road is paved in some sections; however, there are some badly damaged portions and a big level difference in conditions along the route.
33	Avenida Cardeal Alexandre dos Santos	2	Unpaved	This road runs north- south connecting Vila Luisa to Marracuene and Maputo. Although its width is generally wide, the road surface condition is poor and unpaved.

Note: The location of each of these roads is indicated in Figure 2.2 using the road numbers in the table.
Source: JICA Project Team

It is estimated that the existing transport capacity of important arterial roads in urban areas has already become insufficient including along the national roads (i.e., N1, N2) and other arterial roads connecting the Maputo City center and the suburbs (e.g., Av. Julius Nyerere, Av. Vladimir Lenine, Rua Do Jardim, Av. das Industrias). As shown in Figure 2.3, the travel speed at many key sections of these roads is less than 20 km/h during peak hours (see Section 2.2.4 for more detailed results of the travel speed surveys). In addition, the volume-to-capacity ratio (VCR) at some of these sections is estimated to be quite high, indicating the urgent need for transport capacity expansion.



Source: JICA Project Team

Figure 2.3: Results of Travel Speed Surveys and Estimated Volume-to-Capacity Ratios (VCR) along Arterial Roads in 2012

Key points regarding the road network in Greater Maputo include the following:

- Although national roads (e.g., N1, N2 and N4) have been systematically developed in Maputo, their traffic capacity in urban areas has been saturated.
- There are an insufficient number of arterial roads that are complementary to national roads including those connecting national roads and other arterial roads or district roads.
- There is a significant need for increasing traffic capacity (e.g., through roadway widening and pavement improvement) to meet the growing travel demand between the city center and the suburbs especially in the northern and western parts of Greater Maputo.
- In addition, the road network between districts and within districts is insufficient. There are, for example, unfinished roads, causing severe traffic congestion at particular road sections. Also, residential and industrial areas are expected to expand to suburban areas, and a road network which simply connects between districts cannot sufficiently meet the anticipated rapid increase in traffic volume between and within suburban areas.
- For district roads, the proportion of paved roads (pavement ratios) is still very low although there is variation among areas in Greater Maputo. As of 2012, the pavement ratio for district roads was about 36% for Maputo City, 32% for Matola City, 16% for Boane City, and about 15% for the study area of Marracuene District.

2.1.2 Existing Public Transport System

The public transport system in Greater Maputo at present is primarily road-based. There is an extensive network of routes operated by minibuses, known as *"chapas"*, with some full-sized buses, mostly owned by public sector companies, operating on certain routes. These road services are complemented by ferry services between Maputo and Katembe, and across the

Incomati River ferry at Marracuene, and a limited commuter rail service using part of the national rail system.

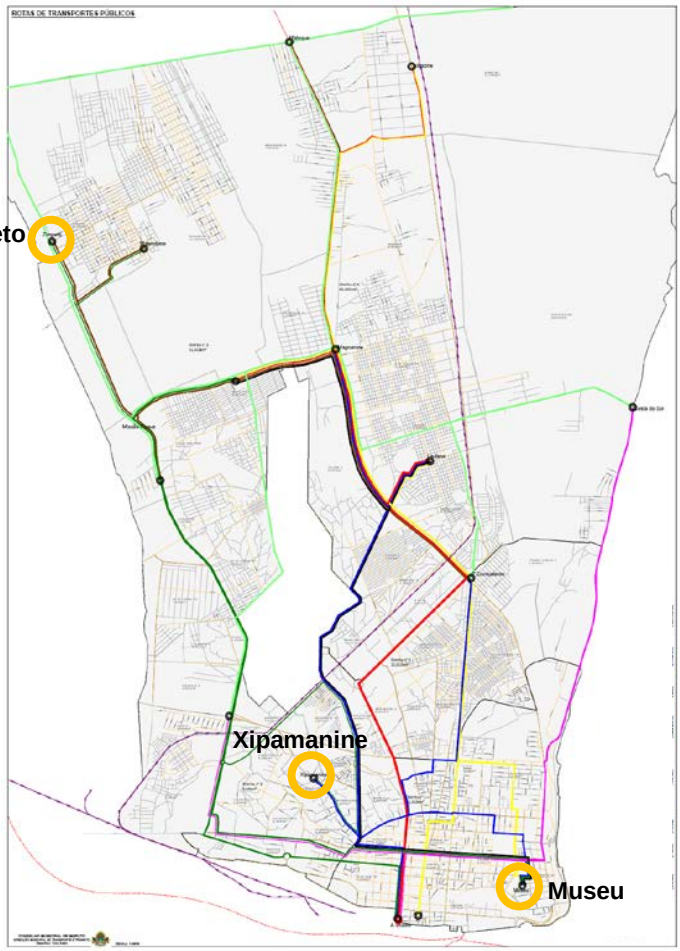
Source: JICA Project Team

Figure 2.4: Buses (Left) and Chapa (Right) – Core Public Transport in Greater Maputo

(1) Chapas

Public passenger transport services in Greater Maputo are provided principally by small private sector operators using vehicles known as "*chapas*", mostly 15-seat minibuses or medium-sized vehicles (midibuses) seating about 25. There are estimated to be between 4,000 and 4,500, *chapas*, operating on approximately 130 routes. Household interview surveys carried out during the study show that approximately 60% of all non-walking trips in Greater Maputo were made by *chapa*, and only 17% by conventional bus.

The *chapa* route network has developed over many years, and was originally based largely on the network operated by Maputo Bus Company (TPM), with additional routes added from time to time. Existing route mapping information, however, is very limited. Figure 2.5 shows a basic map of *chapa* routes in Maputo provided by the Directorate of Municipal Transport and Traffic (DMTT) (not including routes between Maputo and Matola). The map indicates that *chapas* are operated along arterial roads in Maputo, and that the routes indeed overlap with those of TPM presented later in this section though the *chapa* network is more extensive than that of TPM. Since *chapa* operators prefer the more profitable routes, those where demand is low tend to be poorly served.



Note: *Chapa* surveys were carried out at four major *chapa* terminals, three of which were in Maputo as shown in the map, and another at Liberdade in Matola.
Source: DMTT, JICA Project Team

Figure 2.5: Chapa Routes in Maputo

Chapa surveys were carried out during the study at four major chapa terminals including those indicated in Figure 2.5 (in Maputo City) and another located at Liberdade in Matola City. The number of *chapas* operating to/from each of these terminals is summarized in Table 2.3.

Table 2.3: Number of Chapas Operating To/From Each Terminal Surveyed

Terminal	<=15 seats	Truck/ pickup	16–28 seats	>28 seats	Total
Museu	241	19	260	57	577
Zimpeto	488	32	62	59	641
Xipamanine	552	16	14	1	583
Liberdade	264	4	12	10	290

Source: JICA Project Team

Table 2.4 shows the average occupancies of *chapas* departing from these terminals during peak hours, compared with the estimated average seat capacity. As shown, the average occupancy exceeds the estimated capacity nearly consistently during these time periods, indicating the undersupply of *chapa* services in Greater Maputo.

Table 2.4: Average Vehicle Occupancies of Chapas Departing from Surveyed Terminals during Peak Hours

Terminal	Time Period Average Occupancy			Estimated Average Seat Capacity
Museu	15:00–16:00	16:00–17:00	17:00–18:00	
	18.5	26.3	31.3	24
Zimpeto	7:00–8:00	8:00–9:00	9:00–10:00	
	41.4	32.1	36.1	27
Xipamanine	15:00–16:00	16:00–17:00	17:00–18:00	
	17.3	14.8	18.2	15
Liberdade	6:00–7:00	7:00–8:00	8:00–9:00	
	17.5	18.2	14.8	16

Source: JICA Project Team

Key points regarding the existing provision and operations of *Chapas* in Greater Maputo include the following:

- C*hapas* are owned by private individuals, many of whom own only one vehicle. They are rented out to drivers for a daily charge. The driver pays for the direct running costs, including fuel, tyres, minor maintenance and the salary of the conductor, out of the fares collected; the rest is retained as his income.
- C*hapas* are operated on an informal basis on the traditional "fill and go" system, normally waiting at terminals until a full load of passengers has accumulated before departing. This restricts capacity for passenger wishing to board en route.
- Although it is not compulsory, the majority of *chapa* operators are members of one of the associations. The most significant role of the associations is the management of routes and services operated by private sector operators. Their main function in this regard is to control the routes by ensuring that the vehicles used are properly licensed, and that drivers comply with regulations. Each route is controlled by one association. The associations liaise with the municipal authorities in the areas concerned, for example in the planning of routes and the allocation of vehicles to routes, but in practice the associations play a greater role in the regulation of services.
- Most *chapas* are old and poorly maintained, and are in poor condition: many are unsafe. The operators attribute the poor maintenance standards to their financial situation: they claim that fare levels approved by government are inadequate to cover all costs. The *chapa* drivers are responsible for most maintenance. Their contractual arrangement with the vehicle owners, which requires them to bear the cost of all routine maintenance and minor repairs, encourages them to minimise expenditure, and they tend to have the minimum maintenance work done which is necessary to keep their vehicles in operation.
- As a result, many *chapas* may be seen emitting excessive black smoke (which not only creates pollution but indicates excessive fuel and oil consumption), with worn tyres, defective lights, cracked windscreens, broken windows, damaged or missing rear-view mirrors and other defects, and it is likely that other safety-related items such as brakes and steering are also poorly maintained.
- Ineffective safety inspection procedures compound the problem, although more effective enforcement measures implemented recently by the National Institute of Land Transport (INATTER) have resulted in the chapas at the worst condition being taken out of service in Greater Maputo; however, many are reported to have been redeployed to more remote areas where the enforcement of regulations is less strict.

- According to Federation of Road Transport Associations (FEMATRO), about 4,500 *chapas* were licensed and operating in Greater Maputo in 2004. There has been a decline in numbers since, partly due to increasing costs without commensurate increases in fare levels but also because the Maputo municipality stopped issuing licences for minibuses with fewer than 25 seats in 2009. Due to ineffective enforcement many of the 15-seaters continued to operate illegally, without licences; the ruling was reversed in July 2012, and the municipality recommenced licensing the smaller *chapas*.
- In addition, there are many small and medium-sized open trucks without seats operating illegally as *chapas*, mainly at peak periods but some throughout the day; it is difficult to determine how many.

The *chapas* provide an essential service for most people, but the type of vehicle currently used for the majority of services is inefficient and unsuitable for urban services carrying large volumes of traffic. Full-size buses would be more efficient and more suitable in a modern urban environment. This is reflected in current government policy, which discourages the use of small public transport vehicles in city centres, but this policy in practice is currently not being implemented.

(2) Buses

There are approximately 200 full-sized buses operating in Maputo. The majority are operated by the publicly owned Maputo Bus Company (TPM) on approximately 60 routes, while approximately 60 are owned by private individuals, and are operated on a similarly informal basis as the *chapas*. As of 2013, TPM owns approximately 340 buses, but typically operates only about 140 buses daily on services in Greater Maputo due to a backlog of maintenance and shortage of spare parts. As mentioned, household interview surveys carried out during the study show that only about 17% of all non-walking trips in Greater Maputo were made by conventional buses, compared with 60% by *chapa*.

Key statistics of TPM for 2011 are shown in the table below. Although these figures are inconsistent with the 2013 figures above and should be used only as a guide to the company's performance, the substantial difference between the total bus fleet, the operational fleet and the number of buses actually used, indicates very inefficient use of vehicles. These figures also reflect serious maintenance problems, which are due to inherent unreliability of certain types of bus and poor availability of spare parts for the highly diversified fleet. Table 2.6 shows a summary of TPM bus fleet as of April 2012.

Table 2.5: Key Statistics of TPM for 2011

Passengers carried	31,262,000
Total fleet	380
Operational fleet	196
Buses used daily	100
Kilometres operated	8,926,932

Source: TPM

Table 2.6: TPM Bus Fleet Summary – April 2012

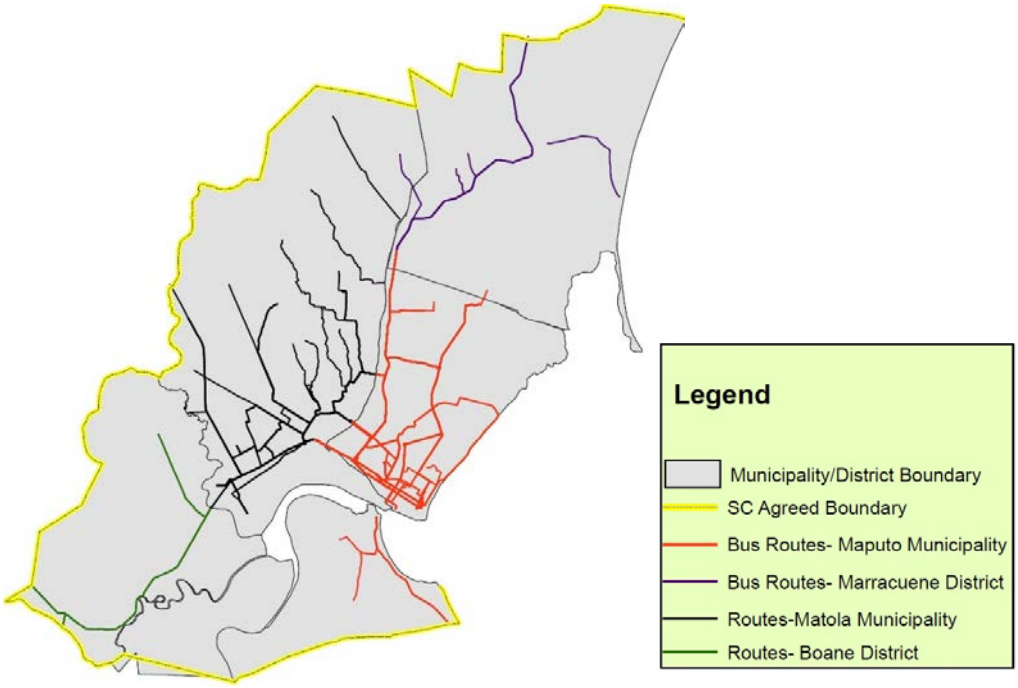
Manufacturer/Model	Passenger Capacity			Year purchased	Number of buses	Number serviceable
	Seated	Standing	Total			
Mercedes 17.24	35	55	90	1994	1	0
Mercedes 13.17	37	53	90	1999	3	0
MAN 18-232 FOC	35	55	90	2006	6	1
Yutong ZK6118HGA	35	45	80	2006	28	3
Yutong Gas	41	34	75	2007	3	0
Yaxing Verde	56	0	56	2007	3	2
Yaxing Vermelho	45	0	45	2007	2	2
Iveco	32	0	32	2007	2	1
Volkswagen 17.210	35	55	90	2008	110	40
Zonda	36	39	75	2008	5	1
MAN Articulated	102	85	187	2010	8	1
Volkswagen 9.150	37	0	37	2010	10	8
Volkswagen 17.210	47	43	90	2010	20	20
MAN 18-232 FOC	54	0	54	2011	1	1
MAN Marcopolo	37	0	37	2011	3	2
TATA Starbus LPO 1613	43	33	76	2011	150	97
TOTAL	-	-	-	-	355	179

Source: TPM

According to the data in 2011, TPM employs 1,324 staff, including 839 drivers and conductors and 200 maintenance staff.

TPM's financial performance is poor, due to a combination of low fare levels and high costs resulting to a large extent from inefficiency in operation, and in particular poor vehicle utilisation. In 2011 its total expenditure was MT 659 million, and revenue from operations only 336 million of which only 176 million was from fares and 152 million from hire of buses; it received a subsidy of MT 266 million.

Figure 2.6 shows a bus route network of TPM in Greater Maputo. This map was prepared based on the transport inventory surveys conducted in this study since an adequate route map was not available at TPM. As mentioned, the TPM routes in Maputo City overlap with those of *chapas*, making these modes in direct competition although the *chapa* network is more extensive than TPM.



Source: JICA Project Team

Figure 2.6: TPM Bus Routes in Greater Maputo

Table 2.7 shows the TPM routes and daily trips for each route that may be operated if the full complement of vehicles (about 350 buses) were available. The average length of the TPM routes (about 60 routes) is 22 km with the planned (not actual) daily trips per route (one way) being about 22 on average, although the actual operation is significantly less than these figures. For example, the information provided by TPM showing the actual situation on a typical day (22 March 2012) indicated a total of some 100 buses operated, on only 59 routes, and the number of buses operated on each route ranged from only one (on 28 routes) to five (on only two routes).

Table 2.7: TPM Routes and Theoretical Allocation of Buses

From	To	km	Daily trips (one way)	Daily kms (both ways)	Theoretical allocation of buses
Pca dos Trabalhadores	Magoanine via Polana	16.0	27	864	6
Pca dos Trabalhadores	Bairro da Liberdade via Jardim	20.0	21	840	6
Museu	Bairro da Liberdade via Jardim	19.0	19	722	4
Anjo Voador	Xipamanine	7.0	27	378	2
Pca dos Trabalhadores	Magoanine	13.0	26	676	8
Museu	Nkobe	26.0	17	884	6
Pca dos Trabalhadores	Nkobe	25.0	17	850	4
Pca dos Trabalhadores	Estadio da Machava	12.0	27	648	4
Pca dos Trabalhadores	George Dimitrov (Benfica)	14.0	27	756	8
Pca dos Trabalhadores	Marracuene	43.0	14	1,204	6
Museu	Marracuene	44.0	13	1,144	6
Pca dos Trabalhadores	Manhica	43.0	15	1,290	6
Museu	Manhica	15.0	27	810	6
Pca dos Trabalhadores	Bairro de Jardim	14.0	26	728	6
Museu	Aeroporto	8.3	34	564	2
Museu	Xipamanine	8.0	27	432	2
Museu	Kongolote	n/k	n/k	n/k	6

From	To	km	Daily trips (one way)	Daily kms (both ways)	Theoretical allocation of buses
Museu	Bairro das Mahotas	16.0	19	608	6
Museu	Laulane	13.0	24	624	6
Pca 25 de Junho	Laulane	12.0	26	624	6
Pca dos Trabalhadores	Laulane via Av Karl Marx	11.0	26	572	6
Museu	Estadio da Machava	13.0	27	702	4
Museu	Matola Gare	26.0	17	884	6
Anjo Voador	Matola Gare	25.0	17	850	6
Museu	Aciplo via Polana	24.0	20	960	6
Pca dos Trabalhadores	Acipol via Hulene	23.0	20	920	6
Xipamanine	Bairro T3	16.0	23	736	4
Museu	Malhazine via Jardim	17.5	23	805	6
Museu	Malhazine via Hulene	17.5	23	805	5
Pca dos Trabalhadores	Malhazine via Jardim	16.5	24	792	5
Pca dos Trabalhadores	Malhazine via Hulene	16.5	19	627	6
Museu	Acipol via Jardim	24.0	20	960	6
Museu	Fomento via Jardim	20.5	22	902	5
Pca dos Trabalhadores	Acipol via Jardim	23.0	20	920	6
Pca dos Trabalhadores	Bairro das Mahotas	17.0	21	714	6
Anjo Voador	Cinema 700	21.3	24	1,022	6
Anjo Voador	Cidade da Matola via Jardim	26.8	21	1,126	6
Pca dos Trabalhadores	Bairro da Liberdade via Jardim	20.0	24	960	6
Pca dos Trabalhadores	Machava Socimol	18.0	21	756	8
Anjo Voador	Bairro T3	14.0	20	560	6
Pca dos Trabalhadores	Patrice Lumumba	16.0	24	768	6
Anjo Voador	Malhampswene	31.8	20	1,272	6
Museu	Bairro T3	15.0	20	600	6
Museu	Mozal via Matola Rio	n/k	n/k	n/k	6
Pca dos Trabalhadores	Matola km 16	16.0	24	768	4
Pca dos Trabalhadores	Boane	35.0	20	1,400	6
Museu	Malhampswene via Jardim	32.8	20	1,312	6
Anjo Voador	Kongolote	n/k	n/k	n/k	6
Museu	Bairro de Liberdade via Jardim	21.0	20	840	6
Anjo Voador	Fomento via Jardim	19.0	22	836	4
Museu	Cidade da Matola via Jardim	27.8	20	1,112	5
Museu	Machava Socimol	19.0	21	798	6
Museu	Boane	36.0	20	1,440	6
Museu	Patrice Lumumba	17.0	21	714	6
Museu	Cinema 700 via Jardim	22.3	21	937	6
Museu	Mozal (Matola Rio)	22.3	21	937	8
Pca dos Trabalhadores	Guava	24.0	21	1,008	4
Museu	Guava	25.0	21	1,050	4
Pca dos Trabalhadores	Pessene	45.0	20	1,800	4
Museu	Pessene	46.0	20	1,840	4
Pca dos Trabalhadores	Albazine via Aeroporto	18.0	21	756	6
Museu	Albazine via Acordos de Lusaka	19.0	21	798	6
Pca dos Trabalhadores	Matendene via Jardim	27.0	24	1,296	6
Pca dos Trabalhadores	Tchumene	36.8	24	1,766	4
Pca dos Trabalhadores	CMC	16.0	25	800	4
	TOTAL	**1,347**		**56,067**	**356**

Note: n/k = not known
Source: TPM, JICA Project Team

Key points regarding the existing provision and operations of buses in Greater Maputo include the following:

- TPM is in the process of being reorganised and divided into new companies under the control of Maputo and Matola municipalities, together with some smaller companies operating in provincial towns. Although the legal change has been made, there has been no physical change to the operation in Maputo, which continues to be managed from the headquarters of the Maputo company.
- As of 2013, TPM owns approximately 340 buses, of a variety of makes and models, mostly less than six years old. Many of the older vehicles are unserviceable due to a backlog of maintenance and shortage of spare parts, and TPM typically operates only approximately 140 buses daily on services in Greater Maputo.
- However, TPM's situation has improved in recent years. The bus fleet has been increased substantially: in mid-2008 approximately 40 buses were operated daily on 24 routes, compared to 140 on 60 routes in 2013; however, the number of buses operated is still a relatively small percentage of the total fleet, with many buses out of service awaiting parts.
- Some full-sized buses are operated in Maputo by private sector operators. A very small number of city buses, imported second-hand, have been operated by individual owners for several years. In July 2011, 50 new buses were imported from India and were allocated to private sector operators.

(3) Taxis and Txopelas

The bus and *chapa* services are complemented by approximately 1,000 saloon car taxis, 300 15-seat taxis operating as school buses, and 200 *txopelas* (three-wheel scooter-based open taxis manufactured by Bajaj in India). The taxis and *txopelas* carry individuals or small groups on a point-to-point basis and do not operate on a shared basis on fixed routes as in many other African countries.

According to the taxi operators' association, the number of taxis is increasing rapidly; there were only 150 three years ago. Taxis are rated according to their quality. Only A-rated taxis may use the stands at the Airport and 4/5-star hotels; B-rated taxis may use other stands in the city, and C-rated taxis are restricted to stands outside the city centre, such as Benfica and Junta.

Txopelas (three-wheel scooter-based open taxis manufactured in India) were introduced in Maputo around 2010. There is no *txopela* operators' association, but FEMATRO estimates that there are about 200 *txopelas* operating in Maputo and Matola, mostly owned by small businesses which rent them out to the drivers. They charge lower fares than taxis (typically MT 35 per km), and there are no set fares. They congregate at busy places such as markets looking for passengers.

(4) Long-Distance Buses

The majority of vehicles used on inter-city bus services from Maputo to cities and towns throughout Mozambique are 15–25 seaters similar to the *chapas* operating in the city, but a small number of full-sized buses are also used on some routes. The majority of international services to neighbouring countries such as South Africa and Swaziland are operated by minibuses with up to 15 seats, mostly with trailers to carry passengers' luggage and freight. Some full-sized buses are also operated; these use only the Junta terminal. In addition, there are luxury international services using full-sized buses operated by companies specializing in such services, mostly based in South Africa.

According to the Cordon line survey carried out during the study (which captures the traffic between Greater Maputo and outer areas as detailed in Section 2.2.3), the N4 site carries the highest number of public transport vehicles among all of the Cordon sites, reflecting the demand for international services to South Africa, followed by the N1 site that carries long-distance traffic between Maputo and the rest of the country (see Table 2.12 for the result of the Cordon surveys).

(5) Rail Transport

Mozambique Ports and Railways (CFM, Portos e Caminhos de Ferro de Mozambique) operates three rail routes from Maputo, to Swaziland via Boane; to South Africa via Matola; and to Malawi via Manhiça. Its primary business is freight transport. Passenger trains stop at all intermediate stations, and carry intermediate local traffic within Mozambique. The section of line between Maputo and Matola Gare is double-tracked; all other lines are single track. Existing rail routes in Greater Maputo are shown in Figure 2.7. Household interview surveys carried out during the study show that only about 1% of all non-walking trips in Greater Maputo were made by rail.

Source: JICA Project Team

Figure 2.7: Existing Railway Routes in Greater Maputo

CFM operates two categories of passenger train: “regular” services (regular long-distance services) with first, second and third class accommodation, and “urban” services, with only third class accommodation (although this is similar to second class on regular trains) for shorter distance commuter traffic. Most regular trains operate only once daily in each direction; some run only on certain days.

Urban services are operated to:

- Manhica (79 kilometres) via Marracuene (2 trains daily in each direction);
- Ressano Garcia (88 kilometres) via Machava and Matola (2 trains daily in each direction);
- Goba (69 kilometres) via Machava and Boane (2 trains daily in each direction); and
- Matola Gare (20 kilometres) via Machava (4 trains daily in each direction).

Three 3-car diesel-electric multiple units (demus) are normally used to operate these services (one on each of the four lines), but availability has been affected by damage by vandals and the full scheduled service is not always operated.

Although there has been a substantial increase in the number of passengers carried on urban trains since 2007 (Table 2.8), the CFM rail system currently accounts for 0.6% of the total trips made in Greater Maputo.

Table 2.8: Passengers Carried on Urban Rail Services

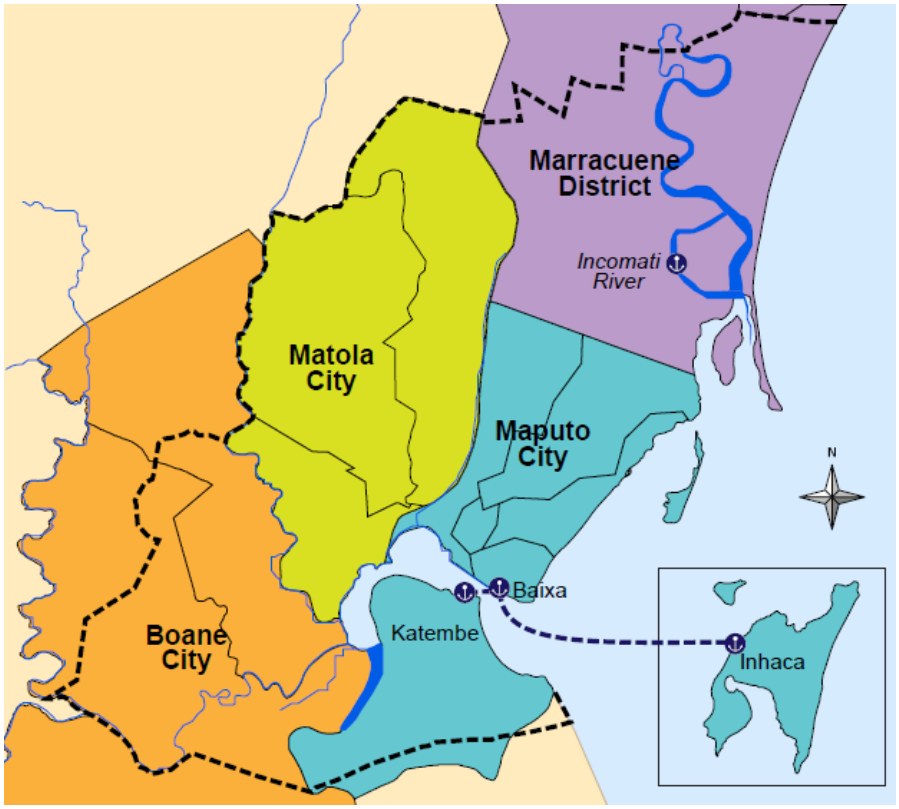
Item	2007	2008	2009	2010	2011
Multiple Units			157,497	255,705	102,059
Loco-hauled trains	450,368	643,169	617,416	1,204,587	1,161,016
Total	450,368	643,169	774,913	1,460,292	1,263,075

Source: CFM

Regarding the financial situation of CFM, approximately 80% of its costs are covered by subsidy and only 20% from freight and passenger revenue. Passenger services are operated to meet social obligations, at very low fares; all local journeys within Greater Maputo on urban trains, or in third class on regular trains, cost MT 5. Most revenue comes from freight, which is the main activity, although passenger services are given priority at the operational level.

(6) Ferries

Transmaritima currently operates two services in Greater Maputo, a ferry for vehicles and foot passengers from Maputo to Katembe, and a service from Maputo to Inhaca for foot passengers only. Both use the same terminal in Baixa. Until October 2010 there was also a service from Maputo to Matola Rio, but this was withdrawn because it was not viable. The Incomati River ferry at Marracuene is operated by Marracuene Municipality. The existing ferry routes are shown in Figure 2.8. There are no other ferry services in Greater Maputo. Household interview surveys carried out in this study show that less than 1% of all non-walking trips in Greater Maputo were made by ferry.



Source: JICA Project Team

Figure 2.8: Existing Ferry Routes in Greater Maputo

There are also some privately operated vessels. There is a service from Maputo to Machangulu (five miles south of Inhaca) and an operator with three boats (capacity 30 passengers each) operating between Maputo and Katembe (using the same terminals as Transmaritima). They operate like the *chapas*, and depart only when full.

Approximately 4,500 passengers and 150 vehicles are carried daily on the Katembe service (22 crossings in each direction), and 75 passengers on each day the Inhaca service which operates four days per week, one return journey.

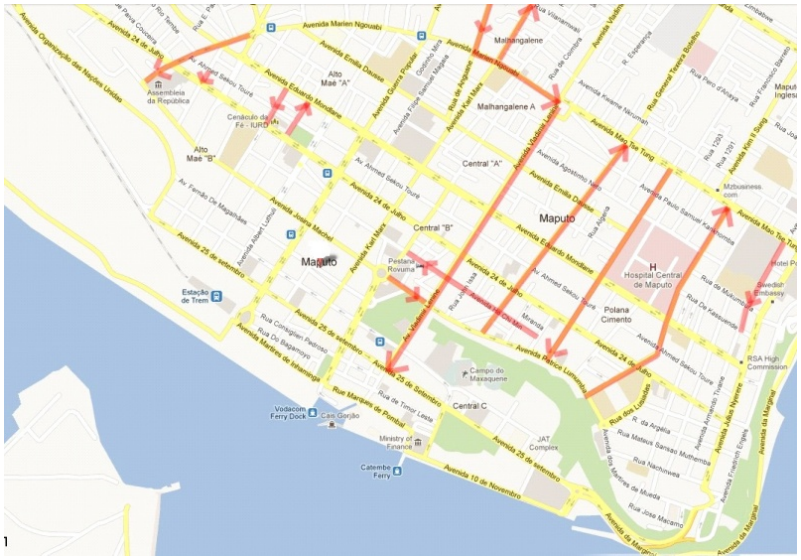
2.1.3 Existing Traffic Control and Management

(1) Operational Changes in the Street Network

Maputo has recently modified central area traffic circulation with several one-way "binary" systems (Figure 2.9). The chief aim has been to simplify turning movements at junctions and eliminate conflicting right turns, yielding efficiency and safety benefits.

However, recent changes in the operation of the central area street network still leave a number of main roads with two-way traffic and a number of junctions with severe capacity restrictions due to permitted right turns.

Another technique implemented in Maputo is tidal flow (fluxo reversível, use of reversible lanes) in which extra road capacity is allocated to incoming or outgoing peak flows. The first operation of this kind in the city was carried out from 6-8 am on the extension of the N2 highway from Matola to Av. 24 de Julho (three inbound lanes and one outbound lane). Within the study area, no specific bus priority measures are in place.

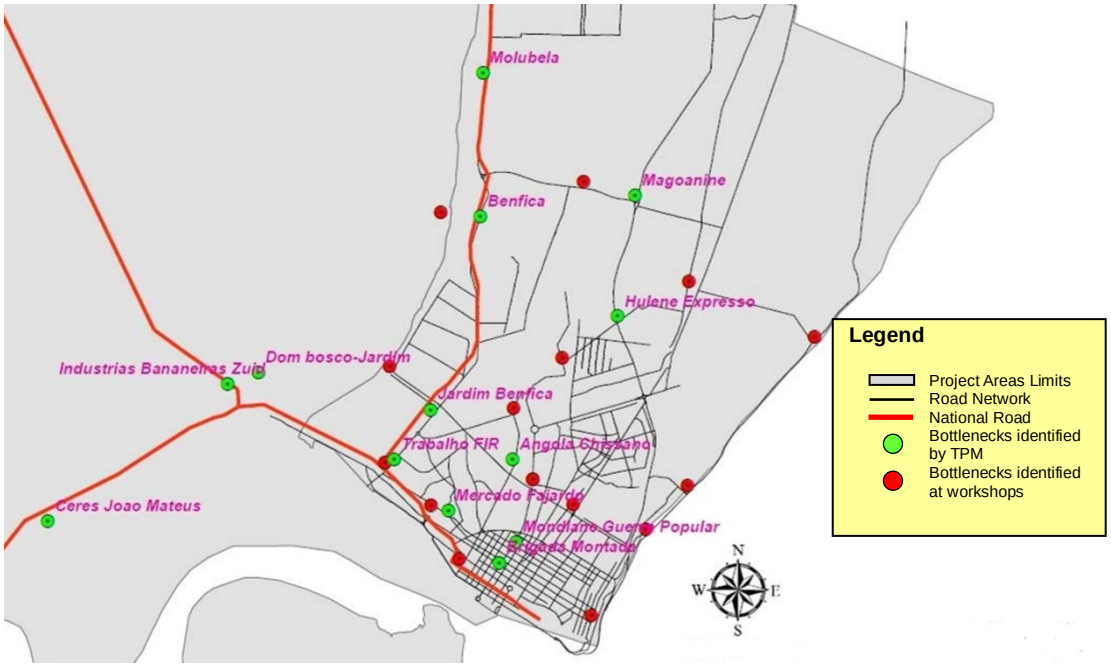


Source: JICA Project Team

Figure 2.9: New One-Way Routes Introduced in 2011

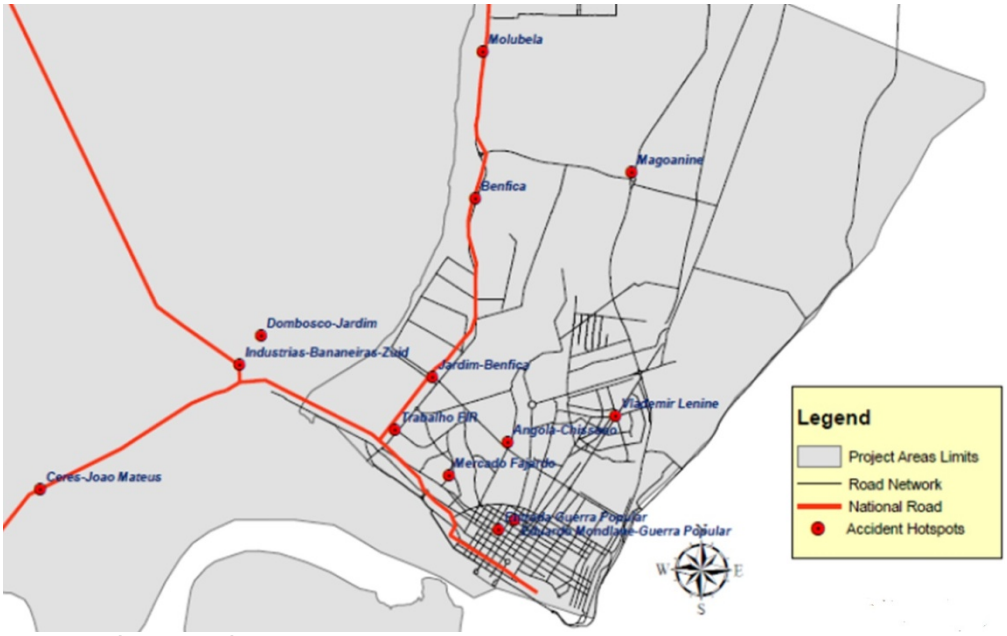
(2) Traffic Bottlenecks

Bottlenecks are traffic congestion "hot spots" where there is an excessive loss of capacity as well as time and public transport capacity, and are a vital consideration in reviewing the traffic management situation. Major traffic bottlenecks were identified as shown in Figure 2.10 based on experiences of TPM bus drivers and technical opinions obtained from the workshops held during the study. These were then visited "in-situ" in order to determine the causes of the problems and to identify options for improvement. In addition, traffic accident hotspots (locations with high accident rates) were identified based on information from the Maputo police (see Figure 2.11). These hotspots are included in the major traffic bottlenecks, with a number of pedestrians, public transport passengers, street vendors, and/or *chapas*. Some of these bottlenecks/hotspots are along the routes where mass transit systems are proposed later in this Master Plan Report; thus they are to be improved as part of the mass transit development. Others would need to be improved as a traffic management measure.



Source: JICA Project Team

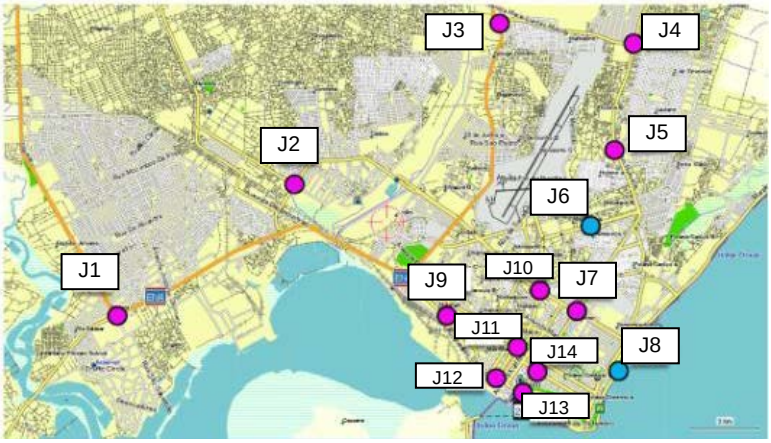
Figure 2.10: Bottlenecks as Defined by TPM Bus Drivers and Workshop Groups



Source: Polícia da República de Moçambique (PRM) – Maputo and JICA Project Team

Figure 2.11: Traffic Accident Hotspots

Traffic counts at major bottleneck junctions (Figure 2.12) were conducted during the study with the results provided in Table 2.9.



Source: JICA Project Team

Figure 2.12: Location of Junction Traffic Counts

Table 2.9: Results of Junction Traffic Counts (24 Hours)

No.	# of Vehicles Entering Junction	Bicycle and Motorcycle	Car and Taxi	Chapa and Minibus	Bus and Coach	Truck
J1	51,866	1%	71%	16%	1%	11%
J2	27,672	2%	60%	24%	1%	13%
J3	31,620	2%	52%	35%	2%	10%
J4	23,925	3%	61%	25%	3%	9%
J5	27,379	4%	59%	27%	3%	7%
J6	27,314	4%	65%	25%	2%	5%
J7	53,155	4%	68%	23%	1%	4%
J8	4,857	4%	90%	3%	0%	2%
J9	44,870	2%	70%	21%	2%	5%
J10	57,322	3%	72%	19%	1%	5%
J11	48,743	2%	55%	38%	3%	2%
J12	45,555	3%	74%	17%	4%	3%
J13	57,037	2%	74%	22%	1%	1%
J14	4,950	4%	46%	38%	2%	11%

Source: JICA Project Team

(3) Traffic Signals and Control Centre

In 2010, Maputo had about 20 traffic signals in operation. As of April 2012, this had grown to almost 50 (including those installed by TRAC), four of which were implemented during recent months and the Directorate of Municipal Transport and Traffic (DMTT) had plans to include another eight junctions soon. The central area signal installations in the central area of Maputo are shown in Figure 2.13.

Source: DMTT

Figure 2.13: Central Area Traffic Signals (April 2012)

Key points regarding the traffic signals in Greater Maputo include the following:

- Currently, the installation of traffic signals is not warranted with no justification for installation existing, although a study has been carried out for each junction where there is a perceived need for signal control.
- Only three signals operate in a synchronized manner (as of April 2012), although the majority possess GPRS (General Packet Radio Service) technology that allows for centralized control. The controllers are supplied by a South African company. According to DMTT, 60% of the signals have a capacity for four traffic plans and 40% for 24 plans. In general, however, only four plans are used – AM peak, PM peak, off-peak, and night plans.
- Most signal heads now have LEDs, which have drastically reduced maintenance costs and theft of light bulbs. By 2013 the DMTT expects that all signals will operate with LEDs.
- Some 30 junctions have detailed installation designs. Cables are run underground through ducts and all access covers are well maintained. To minimize problems of theft, the iron lids are covered by concrete.
- Signals were mentioned several times as major bottlenecks during the driver interview surveys and workshops conducted during the study. This is largely due to the following factors:
  - Signals are at junctions that tend to concentrate *chapa* stops, and these stops in turn create queues that attract street vendors as well as pedestrian crossing flows. As the *chapas* do not like to stop twice, all loading and unloading tends to take place on the signal approaches, greatly diminishing effective green time.
  - Most junctions also operate with all movements permitted, causing 'locking' between conflicting right turns and blocking of approaches.
  - In the central area the signals operate (with few exceptions) without synchronization, causing long queues and waiting times.
- The positive side of signals (during daylight hours) for users in Greater Maputo includes the following:

- Signals are reasonably well respected by all users during the daytime.
- They offer safer opportunities for pedestrians to cross busy streets.
- Green times are not interfered with by traffic police.
- Signal controllers have at least 4 traffic plans in operation (although the timings are not always based on real traffic data or demands).

According to the DMTT, the Operational Control Centre (CCO) was expected to be tendered in 2012 as part of the ProMaputo II Programme. This CCO will include staff from the DMTT, the Municipal Police and the Fire Brigade. The communication between signal controllers and the central command computers will be wireless and special communication towers have been installed.

As well as handling the Area Traffic Control system (ATC), the fibre-optic and GPRS network will offer Variable Message Signs (VMS). The proposed Traffic Control Center will, however, depend largely on pre-programmed timings based on manual traffic counts. Training and software are needed to optimize movements and manage localized congestion.

(4) Parking System

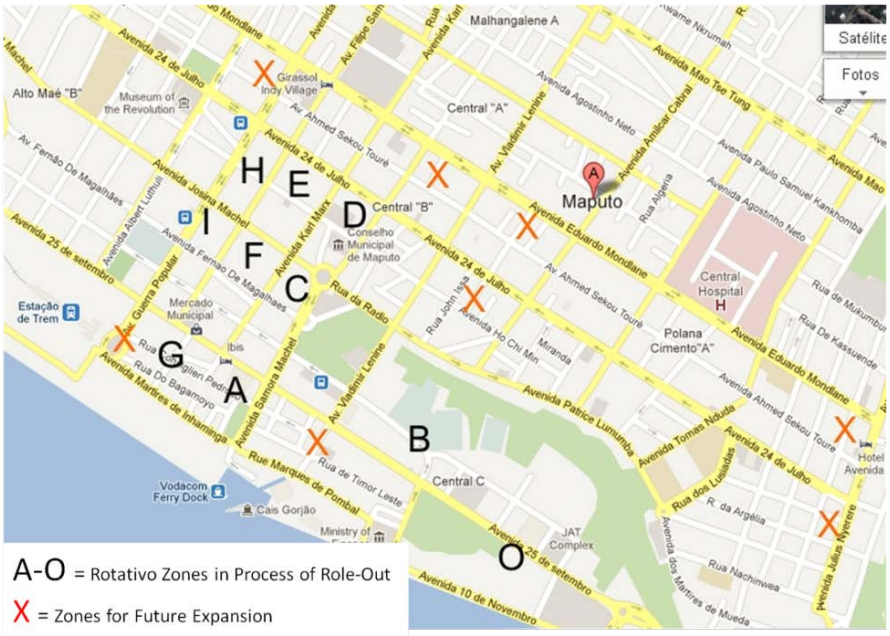
The current short-term parking scheme in Maputo is called “Rotativo”. It promotes short-term parking by the obligatory rotation of demand on marked parking spaces. It therefore enforces short-term stay for parking users, allowing rotation of each space to maximize the efficiency of central area parking spaces. Currently being rolled out, this scheme is intended to cover most of the central business district including 3,700–4,000 spaces in the downtown area to the south of 24 de Julho. According to data for June 2012 supplied by the Rotativo operator, a total of 1,329 parking spaces were under the scheme based on their zonal division (see Table 2.10 and Figure 2.14).

A key parking issue in Maputo is that nonpayment as well as overstaying by users of the parking system is increasing. Therefore, the biggest risk to the success of this system is the lack of enforcement.

Table 2.10: Rotativo Parking Bays in Operation, June 2012 (Rotation by Paying and Non-Paying Parkers)

Area	**B**	**C**	**D**	**E**	**F**	**G**	**I**	**Total**
Spaces	79	340	174	212	241	32	251	1,329
Paid	32,980	163,450	44,590	36,680	75,290	16,760	100,800	470,550
Paid rotation	2.78	3.20	1.71	1.15	2.08	3.49	2.68	2.36
Unpaid	23,520	109,840	36,450	33,390	61,010	12,330	73,250	349,790
Unpaid rotation	1.98	2.15	1.40	1.05	1.69	2.57	1.95	1.75
Total Rotation	**4.77**	**5.36**	**3.11**	**2.20**	**3.77**	**6.06**	**4.62**	**4.12**

Source: Parking4Africa



Source: JICA Project Team

Figure 2.14: Rotativo System Parking Bays by Operational Zone, June 2012

Off-street parking is still limited. Although there is a consensus that off-street parking is needed, there is little incentive for paid off-street parking under the present conditions as users perceive that free on-street parking is still available. There are no fixed rules on the amount of parking spaces to be supplied by new developments, by land use, unit, or constructed area.

2.2 Existing Travel/Traffic Patterns

2.2.1 Overview

Existing travel and traffic patterns were revealed based upon various traffic surveys. The surveys conducted during this project included a household interview survey (HIS), cordon and screenline surveys, travel speed surveys, freight surveys, junction surveys, public transport surveys, and stated preference surveys. The surveys then fed into the development of a JICA System for Traffic Demand Analysis (STRADA) transport model. This section presents major findings of these surveys with more details provided in Technical Report K.

Source: JICA Project Team

Figure 2.15: Greater Maputo Cordon Survey and Household Interview Survey

2.2.2 Household Interview Survey

A total of randomly sampled 10,037 households in Greater Maputo were surveyed; of these 9,983 gave valid responses (response rate of 99.5%). This equated to a total of 38,216 persons over the age of six.

Each household was asked household characteristics including the number of family members, household income, and the number of vehicles owned. Each household member was asked personal characteristics including age, sex, occupation, and daily trip behaviors such as origin/destination, departure/arrival times, trip purposes, and transport modes used. Collected data were error-checked, expanded based on the population by zone, and calibrated with the results of the cordon and screenline surveys conducted. Based on these analyses, OD matrices by trip purpose and trip mode were developed, which were then used for demand forecasting. Important results of the analysis of the 2012 OD matrices are presented in subsection 2.2.6, and the methodology and analyses of demand forecasting are detailed in Chapter 6 and Technical Report N.

Table 2.11 shows the trip rates estimated based on the HIS. The estimated daily trip rate for all households in Greater Maputo was about 1.7 trips per person while the rate for car-owning households (about 13% of all households) is higher, indicating that members of car-owning households make more trips than those not owning cars.

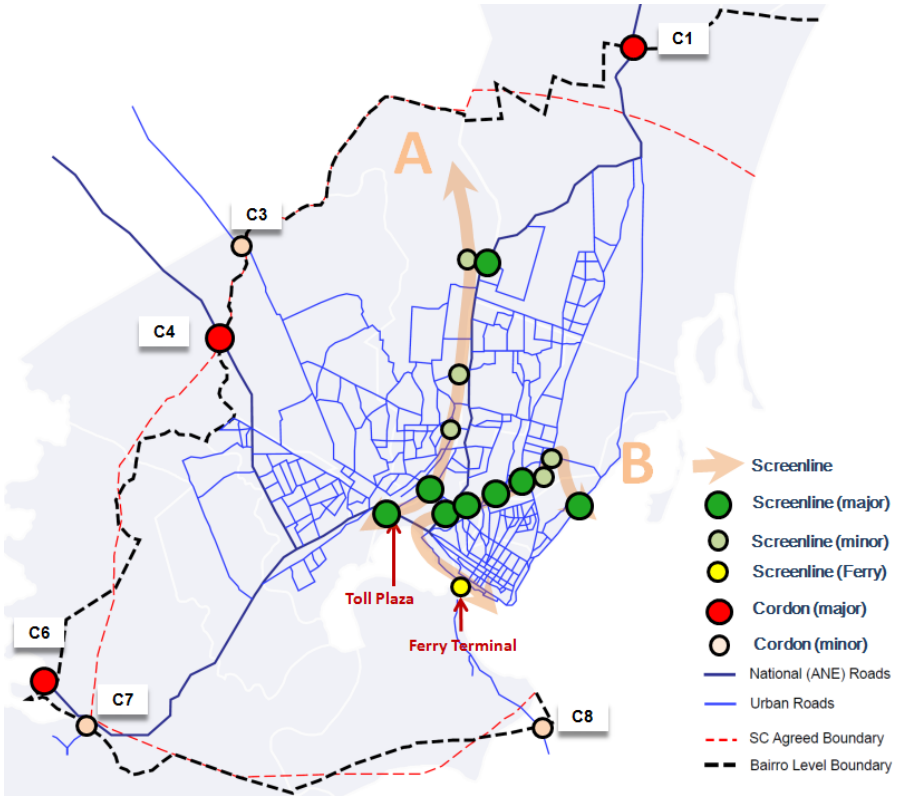
Table 2.11: Trip Rates

Household Type	Daily Person Trip Rate
All Households	1.66
Car-Owning Households	2.15
Non-Car Owning Households	1.61

Source: JICA Project Team

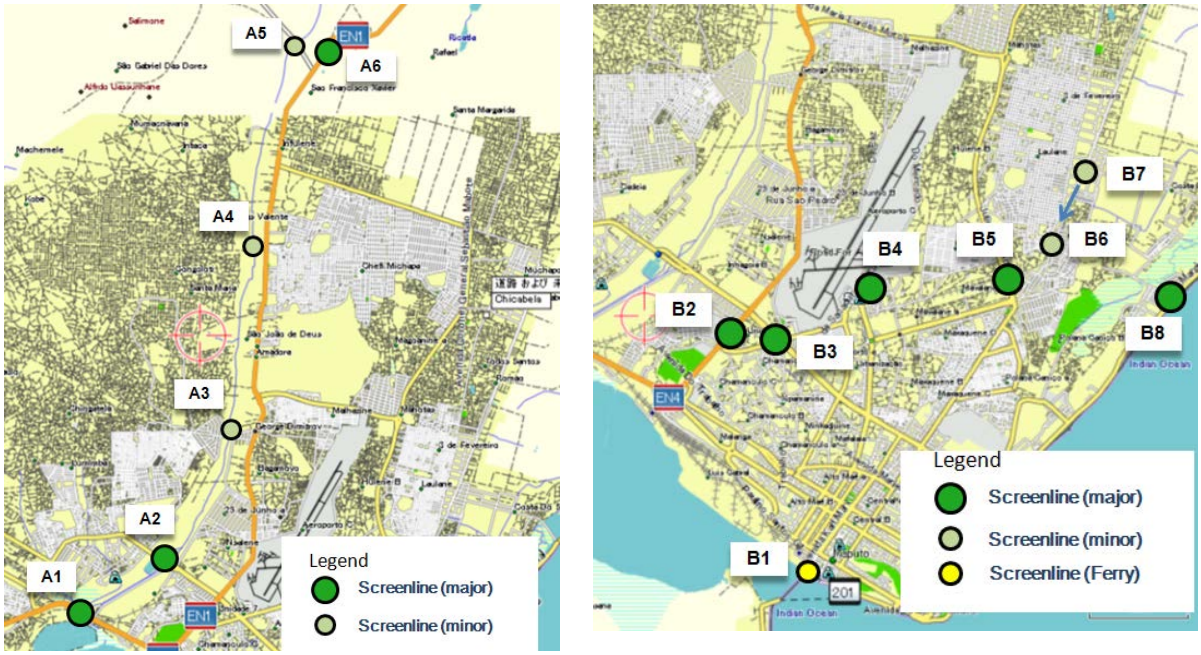
2.2.3 Cordon and Screenline Surveys

Figures 2.14 and 2.15 show the locations of cordon and screenlines used in the traffic surveys. Screenline surveys were conducted within the study area, in order to understand transport movements within the study area and cordon surveys were conducted at the boundary of the study area, in order to understand transport movements into and out of the study area.



Source: JICA Project Team (network background is indicative only).

Figure 2.16: Locations of Cordon and Screenline Surveys



Source: JICA Project Team

Figure 2.17: "A" and "B" Locations of Screenline Surveys

Classified traffic counts were undertaken for 24 hours, 16 hours, or in some cases for a different number of hours. Based on the analysis of hourly patterns at sites with 24-hour counts, traffic counts at sites without 24-hour counts were expanded to 24-hour totals by vehicle type. Two-way daily vehicle flows across the cordon and screenlines are shown in Table 2.12.

Table 2.12: Results of Cordon and Screenline Traffic Counts

Site	Bicycle/ Motorcycle	Car/ Taxi	Chapa/ Minibus	Bus/ Coach	Truck	Total
Screenline A Locations						
A1	385	21,774	8,227	694	3,138	34,219
A2	558	12,119	6,790	718	1,980	22,165
A3	342	4,579	5,422	63	1,390	11,797
A4	167	1,842	1,009	30	310	3,358
A5	68	709	730	10	178	1,694
A6	130	4,673	3,703	196	1,588	10,290
Screenline B Locations						
B1	25	67	91	0	146	329
B2	564	15,983	11,705	875	2,579	31,705
B3	318	9,976	2,645	205	1,000	14,144
B4	269	6,123	3,392	46	1,471	11,301
B5	524	9,649	7,029	540	1,135	18,878
B6	48	1,129	1,083	1	35	2,296
B7	35	883	753	15	132	1,818
B8	209	8,444	1,893	48	2,164	12,757
Cordon Sites						
C1	44	1,765	1,152	142	876	3,978
C3	137	435	312	8	386	1,279
C4	84	4,191	1,980	159	3,542	9,956
C6	81	1,592	615	32	1,202	3,521
C7	337	666	344	49	146	1,543
C8	14	226	173	0	90	504

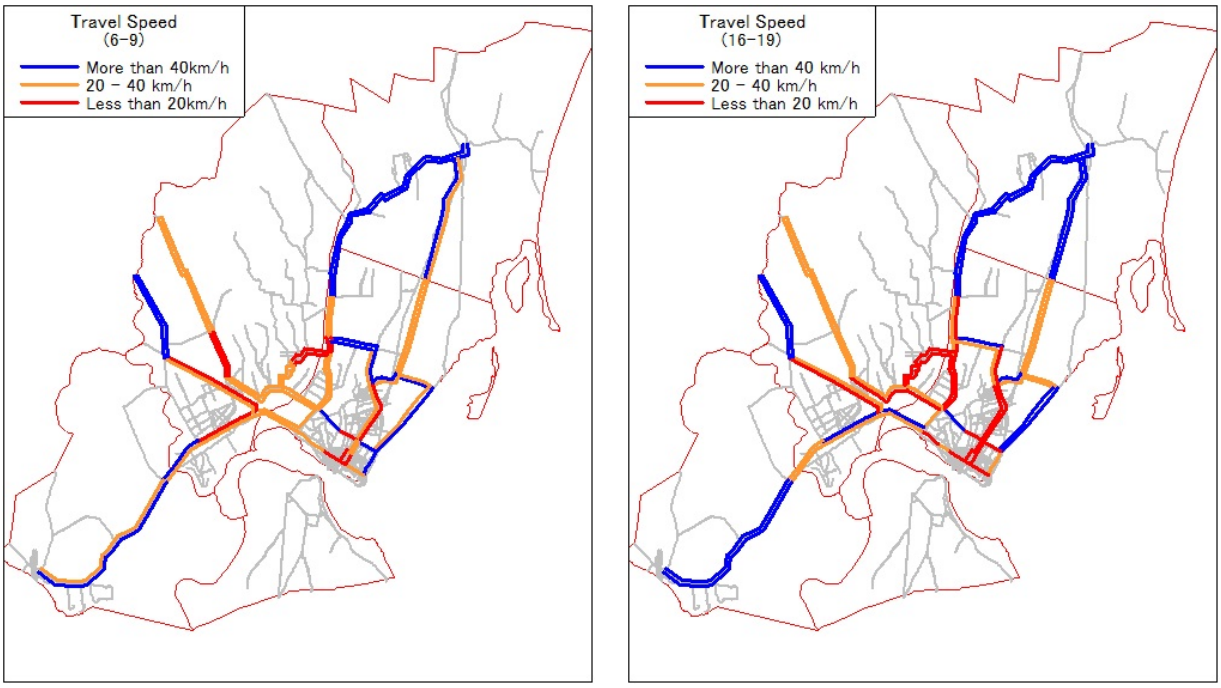
Source: JICA Project Team

The locations with particularly heavy traffic include A1 on N2, A2 on Av. Joaquim Chissano, B2 on N1, and B5 on Av. Julius Nyerere. These are on the arterial roads connecting Maputo and Matola and major roads running north-south within Maputo Municipality.

For the screenline locations, more than half of the vehicular traffic is car/taxi, indicating heavy reliance on private transport modes even though the rate of car ownership is still not high in Mozambique (see Figure 2.1). *Chapa*/minibus dominates public transport while bus/coach accounts for only 10% of public transport modes (and 2% of all vehicles) in terms of traffic counts. Trucks account for about 10% of total traffic counts at the screenline locations, currently not causing major urban transport problems.

2.2.4 Travel Speed Surveys

Along major road sections, congestion has already become serious during morning and evening peak hours. Figure 2.18 presents the results of travel speed surveys conducted during the study. The road sections marked in red are severely congested with an average travel speed of less than 20 kilometers per hour.



Morning (6AM to 9AM) **Evening (4PM to 7PM)**

Source: JICA Project Team

Figure 2.18: Results of Travel Speed Surveys

Key points regarding the results of the travel speed surveys include the following:

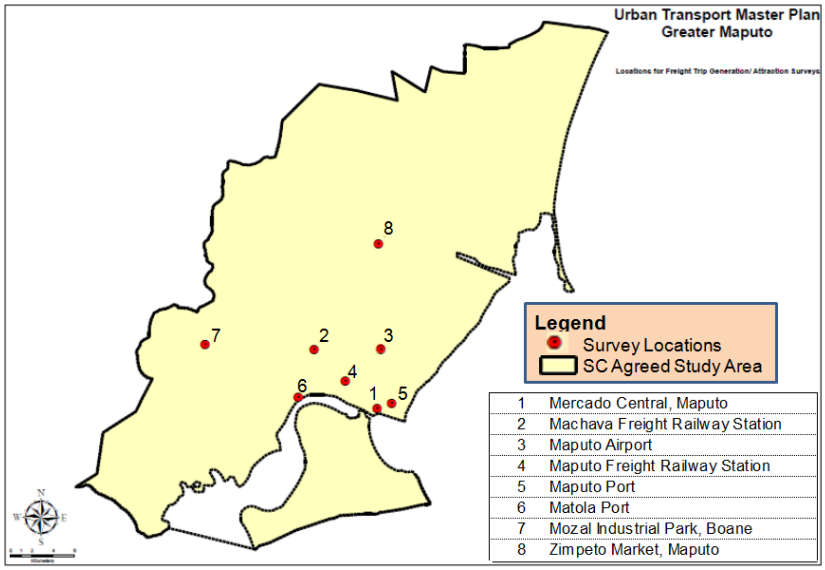
- The arterial roads running between the central business district (CBD) of Maputo and the central and northern part of Maputo Municipality are heavily congested during peak hours. These roads include N1 and Av. Julius Nyerere–Av. Vladimir Lenine. The population is expected to grow rapidly in northern Maputo including the Zimpeto area and northeastern Maputo (both identified as a growth center in Chapter 4 of this report), which will further increase the travel demand along the N1 and the route of Av. Cardeal Alexandre dos Santos–Av. Julius Nyerere–Av. Vladimir Lenine. **The expansion of traffic capacity along the North-South Axis in Greater Maputo is a major transport issue that must be addressed in the Master Plan.**
- There is a serious lack of traffic capacity on the arterial roads linking Maputo and Matola (i.e., extending in the east-west direction) including Rua Do Jardim–R807; Av. 24 de Julho–N2; and Av. das Industrias. The areas along R807 and Av. das Industrias are undergoing industrial and residential developments, and identified as one of the growth centers in Chapter 4 of this report. It is expected that the travel demand will increase further between these areas and the Maputo CBD. **The expansion of traffic capacity along the East-West Axis in Greater Maputo is a major transport issue that must be addressed in the Master Plan.**
- The lack of traffic capacity also causes peak hour congestion along the route linking central/northern Maputo and Matola, both expected to experience rapid population growth. While the (outer) Ring Road Project is undergoing, a major Maputo-Matola link located between the Ring Road and the urban areas of Maputo needs to be developed in order to meet the suburb-to-suburb travel demand that will increase further.
- In addition, the above results indicate that some of the traffic bottlenecks shown in Section 2.1.3 worsen the congestion including the junctions at: N2–Rua Do Jardim; Rua

Do Jardim–Av. das Industrias; N2–N4; and N1 –Av. Joaquim Chissano. Improvement measures for these bottlenecks should be implemented either as an independent traffic management project or as part of a public transport improvement project.

- Introducing quality public transport systems together with the implementation of various traffic management measures is essential to alleviate the chronic congestion within the Maputo CBD, which also is indicated in the above results.

2.2.5 Freight Surveys

Freight surveys comprising classified vehicle counts (by goods vehicle type) and road-side interviews with these vehicles were conducted at major locations generating and attracting freight traffic in order to better understand freight movements within the study area. The survey locations are shown in Figure 2.19.



Source: JICA Project Team

Figure 2.19: Freight Survey Locations

Table 2.13 shows the daily goods vehicle trip matrix obtained from the surveys at these locations. More than half (about 56%) of the total freight traffic to/from these locations travels between Maputo and Matola, 17% between Matola and Boane, and 11% between Maputo and outside of the study area, which mostly is considered the traffic between Maputo and South Africa.

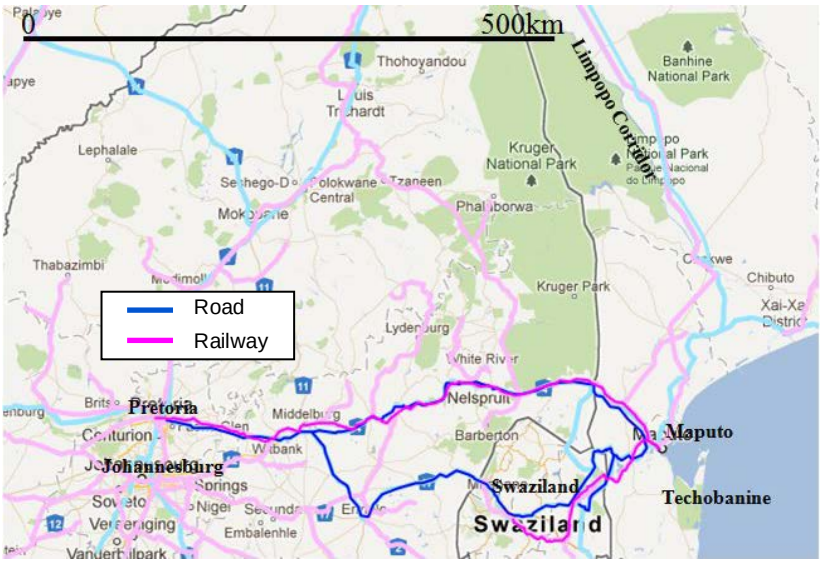
Table 2.13: Daily Goods Vehicle Trip Matrix for All Vehicle Types

From:	To:	Maputo	Matola	Marracuene	Boane	External	Total
Maputo		1,437	1,920	48	349	561	4,316
Matola		2,339	1,370	100	1,257	143	5,208
Marracuene		65	23	0	23	7	118
Boane		620	814	39	53	88	1,614
External		815	275	79	108	15	1,292
Total		5,277	4,401	267	1,790	814	12,549

Source: JICA Project Team

According to the cordon and screenline traffic counts shown in Table 2.12, the route N4 carries the highest number of trucks (3,542 trucks at C4) among all of the survey points. Since C4 is a cordon site, most of these trucks are considered the traffic between Maputo and South Africa.

Maputo is a gateway city of the Maputo Corridor, one of the major economic corridors in the Southern African region. As shown in Figure 2.20, the corridor links Maputo and the capital area of South Africa that is by far the largest economy in the region.



Source: http://www.tmsagis.co.za/

Figure 2.20: Maputo Corridor

The Port of Maputo is the closest port from the capital area of South Africa, even closer than South African ports including Durban. In 2011, Maputo Port handled about 12 million tons of cargo, of which 40% was for national import/export and 60% for transit, with 93% of the transit being for South Africa.[1]

In 2012, the throughput of the port reached 15 million tons, the highest ever achieved, and again the port handled a record volume in 2013, exceeding 17 million tons.[2] In its strategic plan, the port sets out a target of reaching 40 million tons by 2020.

While much of the cargo handled by the port is transported by freight railway (including coal), a significant increase is expected in the handling of general cargo and containers, leading to a rapid growth in truck traffic between the port and South Africa (transit) and within Mozambique (national import/export).

Moreover, South Africa is the biggest trade partner for Mozambique among the SADC countries, and the transport demand along the Maputo Corridor that is originated or destined in Greater Maputo (not going through the port) is also expected to grow further.

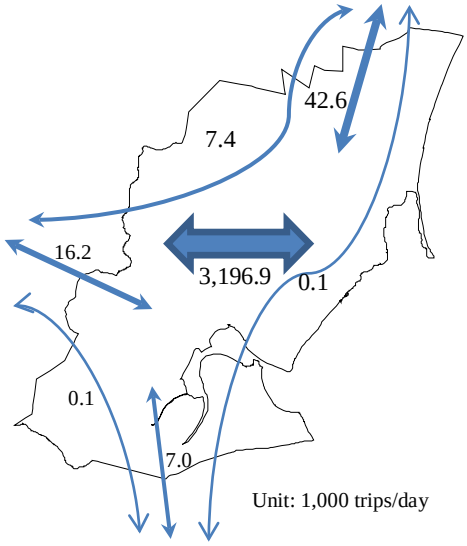
In view of these trends, the urban transport in Greater Maputo should meet the growth in freight transport especially between Maputo and South Africa, for example, by expanding the transport capacity along the Maputo–Matola routes that would otherwise be a major bottleneck for the

[1] Source: JICA, Data Collection Survey of Economic and Industrial Development along Economic Corridors in Southern Africa, Final Report, May 2013.
[2] Source: http://www.portmaputo.com/

logistical operation along the Maputo Corridor. The improvement in Maputo–Matola transport is also important for industrial development in the Matola area, which is located along the route toward South Africa, thereby avoiding the freight transport between the area and South Africa passing through the urban areas of Maputo.

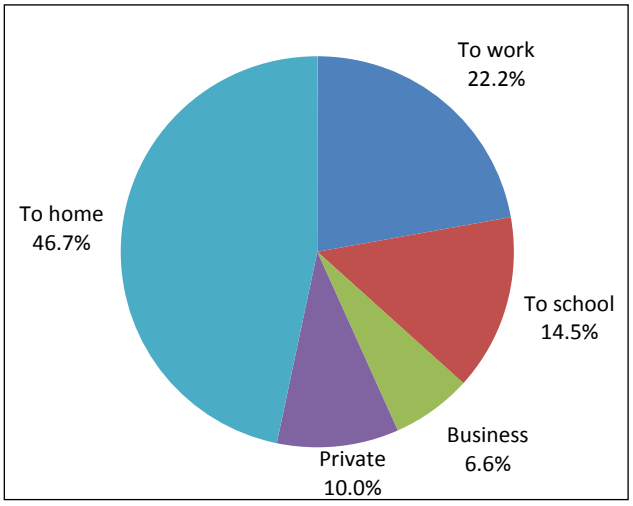
2.2.6 Overview of Travel Patterns

A total of 3,270,300 trips per day are undertaken, 3,196,900 of which were wholly within the study area. A total of 1,422,600 of these trips are non-motorized (i.e., walk-only or bicycle). Figure 2.21 shows the overall daily travel pattern across Greater Maputo. The proportions of different trip purposes are shown in Figure 2.22, while modal split (including walk and bicycle trips) is shown in Figure 2.23.



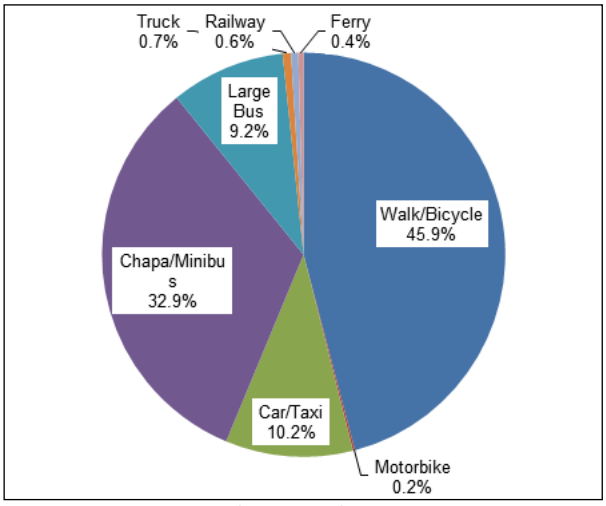
Source: JICA Project Team

Figure 2.21: Overall Existing Travel Patterns



Source: JICA Project Team

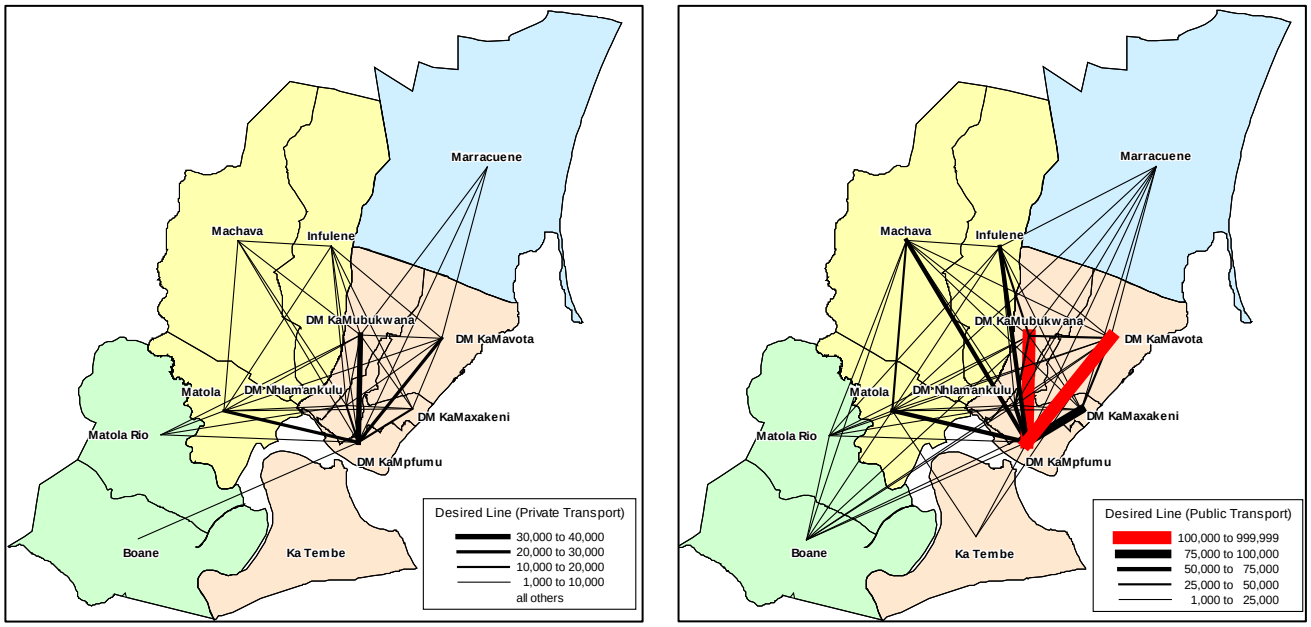
Figure 2.22: Existing Trips by Purpose



Note: Bicycle accounts for 0.3% of all trips.
Source: JICA Project Team

Figure 2.23: Existing Modal Split

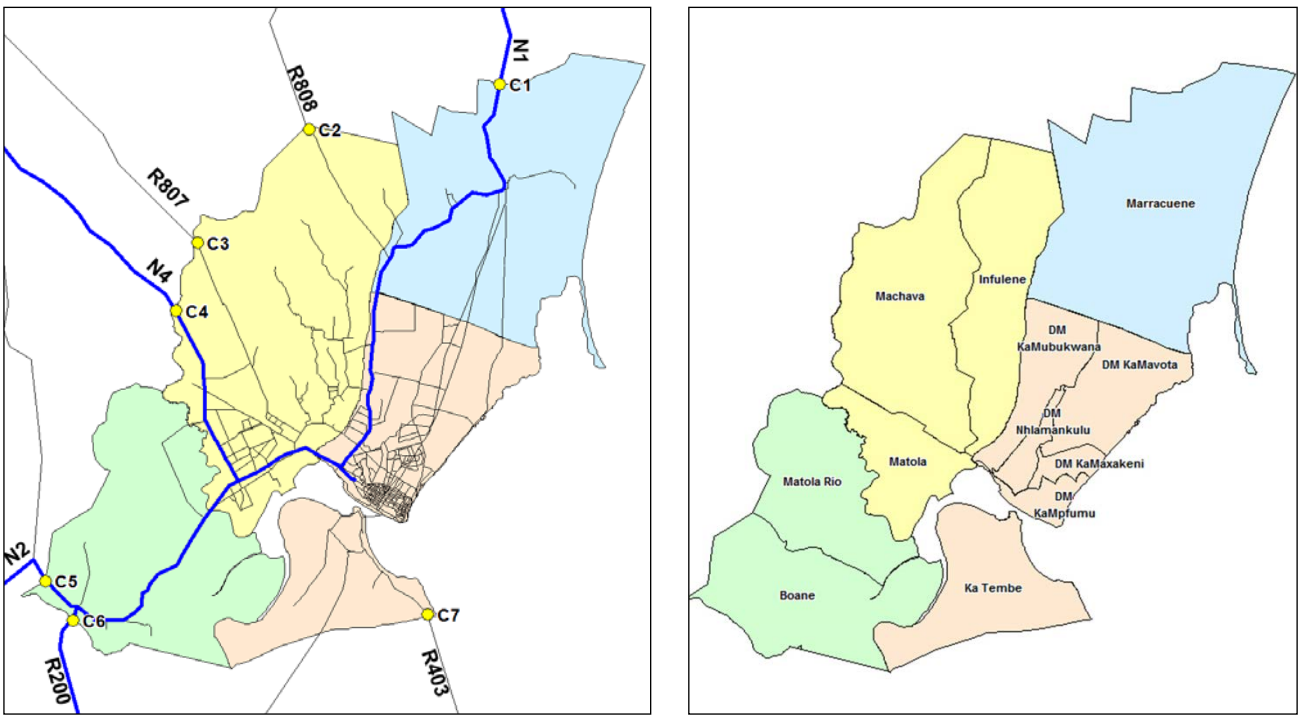
Travel desire lines for private and public transport modes estimated for 2012 are shown in Figure 2.24. In order to better understand the travel patterns represented by these lines, major road network and the districts in the study area are provided in Figure 2.25.



For Private Transport **For Public Transport**

Source: JICA Project Team (System for Traffic Demand Analysis [STRADA] transport model)

Figure 2.24: Estimated Travel Desire Lines in 2012



Note: C1-C7 are the locations for the Cordon line surveys.
Source: JICA Project Team

Figure 2.25: Major Road Network and Districts in the Study Area

Major travel patterns observed from the desire lines include the following:

- There is a heavy travel demand between the CBD of Maputo and the central and northern part of Maputo Municipality, specifically DM KaMubukwana and DM KaMavota Districts, causing severe congestion along the arterial roads running north-south including N1 and Av. Julius Nyerere–Av. Vladimir Lenine (see also the results of travel speed surveys in Section 2.2.4). The Zimpeto area in DM KaMubukwana District and northeastern Maputo in DM KaMavota District are identified as a growth center in Chapter 4 of this report.
- The travel demand between Matola and Maputo is also quite high. A high level of travel demand is generated from wide areas in Matola Municipality including Matola District located in the south of the municipality, southern part of Machava District, and southern part of Infulene District. These areas are undergoing industrial and residential developments, and identified as one of the growth centers in Chapter 4 of this report. The traffic between these areas and the CBD of Maputo causes severe congestion along the arterial roads running east-west including Av. 24 de Julho, N2, N4, Av. Joaquim Chissano/Rua Do Jardim, R807, and Av. Industrias (see also Section 2.2.4).
- These travel patterns and the extent of congestion described in Section 2.2.4 indicate that significant expansion of transport capacity should be urgently implemented along the North-South and East-West Axes in Greater Maputo.
- The demand for suburb-to-suburb travel can also be observed between certain areas (though considerably lower than the above two) including between Machava and Matola and between central/northern Maputo Municipality and Matola/Machava. As mentioned above, both central/northern Maputo and Matola are expected to experience rapid growth, which will lead to a substantial increase in the suburb-to-suburb travel demand.

2.3 Key Urban Transport Issues/Challenges

2.3.1 Major Issues/Challenges

Table 2.14 summarizes major issues and findings on existing urban transport conditions in Greater Maputo based on the surveys conducted during this study.

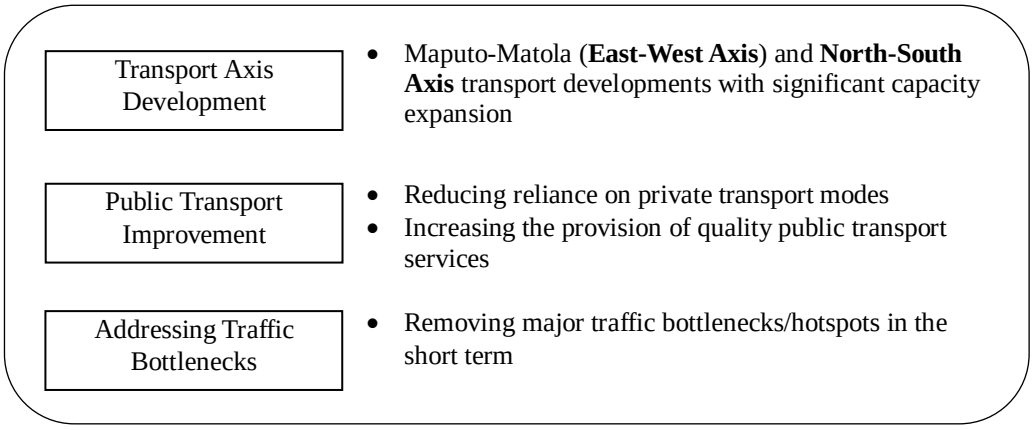
Table 2.14: Major Issues and Findings on Existing Urban Transport Conditions

Issue	Major Findings (Sources)
Transport between Maputo CBD and central/northern Maputo Municipality	• Travel demand is quite heavy in the north-south direction within Maputo Municipality. (Figure 2.24) • Arterial roads running north-south including N1, Av. Julius Nyerere and Av. Vladimir Lenine are severely congested during peak hours, indicating a serious lack of transport capacity along north-south transport links.(Figure 2.18)
Transport between Matola and Maputo	• Travel demand between Matola and Maputo is also quite heavy with a high level of traffic generated from wide areas in Matola Municipality. (Figure 2.24) • Major roads connecting Matola and Maputo are severely congested during peak hours, indicating a serious lack of transport capacity along east-west transport links. (Figure 2.18) • The majority of freight traffic in Greater Maputo flows between Maputo and Matola/beyond. Serious congestion along east-west links leads to inefficient freight movements in Greater Maputo. (Section 2.2.5)

Issue	Major Findings (Sources)
Suburb-to-suburb transport	• Suburb-to-suburb travel demand is fairly high between certain areas (e.g., between central/northern Maputo Municipality and Matola/Machava), though still considerably lower than the above two. (Figure 2.18, Figure 2.24)
Issues on modal share	• Vehicular traffic in Greater Maputo relies heavily on private transport modes, indicating the undersupply of quality public transport services. (Figure 2.1, Table 2.9, Table 2.12) • *Chapa*/minibus dominates public transport while bus/coach accounts for only a fraction of public transport modes in terms of traffic counts. (Figure 2.1, Table 2.9, Table 2.12)
Issues on freight transport	• Trucks account for about 10% of total traffic counts at the screenline locations, currently not causing major urban transport problems. (Figure 2.1, Table 2.12) • As mentioned above, the majority of freight traffic in Greater Maputo flows between Maputo and Matola/beyond, and serious congestion along east-west transport links leads to an inefficient overall freight transport in the metropolitan area. (Section 2.2.5)
Traffic bottlenecks	• Traffic bottlenecks causing an excessive loss of transport capacity were identified in and around Maputo CBD. Removing major bottlenecks is required in the short term. (Figure 2.10, Figure 2.11)

Source: JICA Project Team

Figure 2.26 shows major development initiatives urgently needed to address these overall urban transport issues faced by Greater Maputo.



Source: JICA Project Team

Figure 2.26: Major Development Initiatives Urgently Needed in Greater Maputo

More specific existing issues and challenges are described in the subsections that follow, including those on road network, public transport, traffic management, and capacity/institutional development.

2.3.2 Existing Road Network Issues/Challenges

While national roads such as N1 and N4 have been developed continuously, in urban areas, there are roads (including several sections of these national roads and municipal roads) that are chronically congested due to heavy traffic caused mainly by increased inflow traffic at key junctions and a lack of alternative routes.

There are a variety of interlinked causes of traffic congestion in Greater Maputo, including:

- an insufficient number of major arterial roads and substitute detour roads
- an insufficient road network for traffic distribution
- insufficient traffic capacity considering the number of lanes and poor surface condition
- roads with missing sections and unused roads
- intersections with low traffic capacity and unsuitable signal split times
- traffic obstructions caused by vehicles parking on the street and *chapa* stops

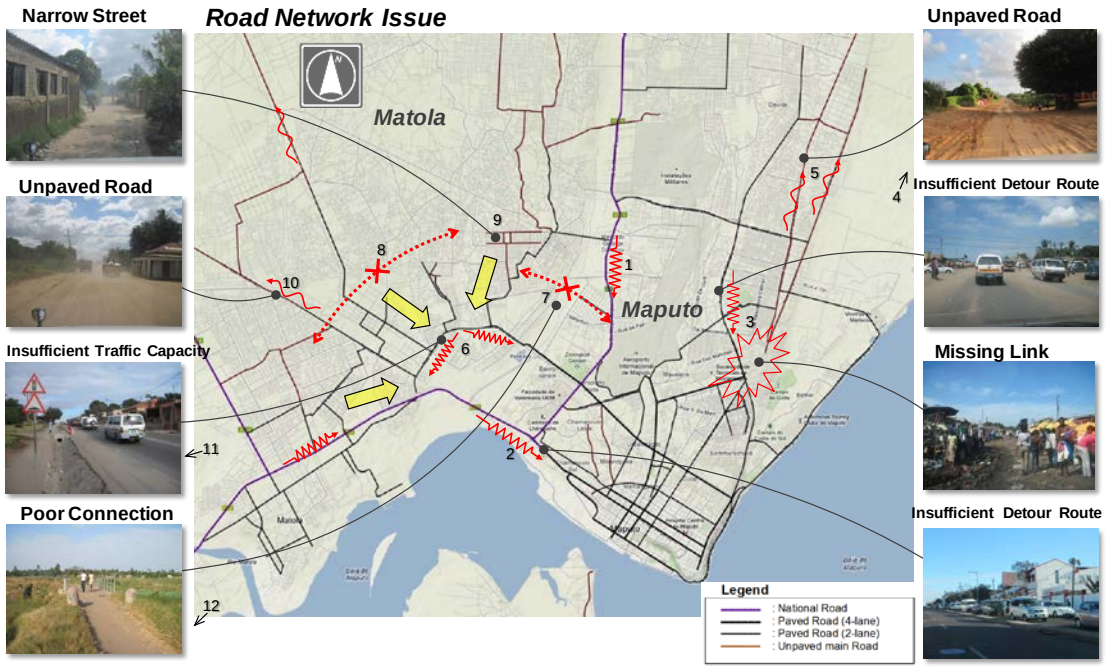
All national roads have asphalt pavements, and the road surface conditions are comparatively good. Except for potholes and partly damaged road edges, an acceptable level of ride quality on the national network is maintained. A high proportion of municipal roads in urban areas are paved, but they also are severely congested due to a lack of adequate road maintenance. In suburban areas, the proportion of roads that are paved is low with poor conditions and narrow widths.

Further information regarding existing road conditions and issues are outlined in Table 2.15 and Figure 2.27.

Table 2.15: Current Situation of the Road Sector in Greater Maputo

	Route/Location	Summary
1	N1/Maputo	Although the N1 in Maputo was widened to four lanes, it is heavily congested due to heavy traffic volumes and continuous flow intersections.
2	N4/Maputo–Matola	Although the N4 between Maputo and Matola was widened to four lanes, it still carries heavy traffic volumes and the detour route is still undeveloped. Thus, it experiences serious traffic congestion during peak hours.
3	Eastern Airport North–South Route	The eastern airport area experiences concentrated traffic, but this route has a low capacity and requires an upgrade.
4	Maputo New Northeastern Residential Area	New residential areas will be developed in northeastern Maputo. However, there are almost no connecting roads, and roads are either narrow or in poor condition to accommodate vehicular traffic.
5	North–South Route of Maputo–Marracuene	Since the north-south route connecting Maputo/Marracuene has poor/unpaved roads, accommodating increases in vehicular traffic on this route is difficult.
6	Matola Av. Eduardo Mondlane (Rua Do Jardim)	Although it is a competing route with N4, this route only has two lanes and some signalized intersections in Machava; thus, it experiences heavy traffic congestion.
7	Greenbelt Areas between Maputo and Matola	The greenbelt areas between Maputo and Matola have few road crossings that can accommodate vehicular traffic. These are also in poor condition and the main route suffers from similar conditions and longer trips due to detours.
8	Southern Matola Area	Matola is divided into three districts with the network divided by topography and rail.
9	Matola Urban Area	Matola urban area has many access roads, but few roads can be passed by vehicles. Moreover, the only arterial street in the area has many cracks and is in poor condition.
10	Industrial Route of Matola Sede–Machava	Factories are located along R807 and Av. Industrias. In the western area, issues include long travel times, falling loads, and traffic dust along unpaved roads.
11	Matola Rio Residential Area	The road network in Matola Rio is insufficient due to advancing residential development and the development of Mozal Industrial Park,
12	Bridge of R200/Boane	Vehicles cannot cross the deteriorating bridge over the Umbulzi River.

Source: JICA Project Team



Source: JICA Project Team

Figure 2.27: Summary of Key Road Network Issues

In summary, the main road network issues and challenges in Greater Maputo include the need to:

- upgrade and develop the road network to address connectivity issues
- reduce traffic congestion
- improve poor road surface conditions and develop a better maintenance system
- improve road safety
- provide for natural disaster resilience

2.3.3 Existing Public Transport Issues/Challenges

Public transport service levels and quality in Greater Maputo are poor and compounded by a wide range of issues and challenges, specifically as follows:

- The public transport system in Greater Maputo is inefficient, causing a severe lack of transport capacity especially along major routes. C*hapas* account for about 60% of all non-walking trips while only 17% of these trips are made by conventional buses (see Figure 2.23). In addition, cars/taxis account for 19% of these trips, which is even higher than that of conventional buses. The improvement in service quality and capacity expansion are seriously needed in the public transport system in Greater Maputo.
- As described in section 2.1.2(1), the *chapa* route network in Greater Maputo has developed piecemeal over many years, and does not necessarily reflect present requirements. It overlaps with the network of TPM, and the division of functional responsibilities has not been considered between these modes. In addition, since *chapa* operators prefer the more profitable routes, those where demand is low tend to be poorly served.
- There is a significant lack of quality fleet in the public transport sector in Greater Maputo. Most *chapas* are old and poorly maintained, and are in poor condition. For

TPM, the number of operational fleet is substantially less than the total bus fleet it owns (see section 2.1.2(2) for details).

- There are various informal features in the *chapa* industry including the following (see also section 2.1.2(1)): in practice, operators' associations play a greater role in the regulation of the *chapa* industry than the municipal authorities (e.g., planning of routes, allocation of vehicles to routes); *chapas* do not run to schedule but are operated on an informal basis on the traditional "fill and go" system; *chapas* are owned by private individuals, many of whom own only one vehicle; many of them operate illegally without licences; and there are many small and medium-sized open trucks without seats, operating illegally as *chapas*. These features cause various problems including: a lack of reliability, long waiting times, overcrowding, safety and security issues, inconvenient routing, poor accessibility, route cutting, forced interchanges, poor vehicle condition, low safety standards, and a lack of comfort.
- TPM's financial performance is poor, due to a combination of low fare levels and high costs resulting to a large extent from inefficiency in operation, and in particular poor vehicle utilisation.
- There is an almost total lack of formal public transport infrastructure in Greater Maputo with few designated intermediate stopping places for buses and *chapas*; the *chapas* in particular tend to stop at any point at the convenience of the driver to pick up and drop off passengers, with little regard for safety or traffic conditions.
- In order to achieve a well-organized and efficient mass transport system, the public transport industry must make the difficult transition from the existing system, which is largely informal as summarized above, to one in which all mass transport services (buses, rail, or waterborne) are operated by formal businesses, appropriately planned and regulated.
- The capacity of the institutions and organizations responsible for delivering public transport services, both in the public and private sectors, is limited, which severely constrains the effectiveness of the system. Most of the organizations involved in the delivery of public transport services lack the necessary resources (e.g., suitably qualified personnel, equipment, funding) to carry out their tasks effectively.

In summary, the main public transport issues and challenges in Greater Maputo include the need to:

- increase public transport capacity on key routes
- redesign the route network to better meet Greater Maputo's requirements and to make optimal use of vehicles
- improve service levels, particularly reliability and service quality
- upgrade public transport infrastructure provision (e.g., stops/terminals)
- review fare level and structure and improve cost recovery
- restructure and reorganization of the public transport industry
- improve enforcement of rules and regulations
- develop capacity in the public transport sector

2.3.4 Existing Traffic Management Issues/Challenges

Bottlenecks are traffic congestion hotspots where there is an excessive loss of capacity, time, and public transport capacity. Key bottlenecks in the study area are outlined in section 2.1.3 (2), but essentially they constrain the network, reduce efficiency, cause delays for private and public transport and environmental problems. Other compounding factors include the loss of capacity

due to encroachment, with pedestrians forced onto the road by vendors and irregular stopping of *chapas*.

Traffic control issues in Greater Maputo are diverse and include the lack of clear warrants for signals in terms of flows or accident rates. Green times are not fully optimized, the capacity of the controllers to operate special traffic plans is underused, and conflicting right turns are a problem.

The increase in traffic volume and car ownership has greatly increased the number and severity of accidents in Greater Maputo, which is recognized as a major public health problem. Specific road safety issues include the following:

- The great majority of road deaths are from pedestrian knockdowns
- There is a concentration of road deaths between 3 am and 6 am
- There is a high concentration of serious pedestrian accidents on several main arteries (accident hotspots are mapped in Technical Report G)
- There is a lack of road safety measures, infrastructure, and education
- There is a lack of a digital accident database

Finally, as mentioned, issues and challenges relating to parking in Greater Maputo need to be addressed, including the following:

- The rotativo system for short-term parking covers about 3,700–4,000 spaces to the south of Av. 24 de Julho.
- The greatest issue facing this type of system is enforcement – nonpayment and abusive overstaying are a problem.
- Off-street parking is very limited. As yet there is very little off-street parking within the main commercial zones due to the perception that on-street bays are available and largely free and that sidewalks can be used with impunity for parking.
- Sidewalks have become de facto parking areas. Sidewalk maintenance is also a major problem that is exacerbated by the passage of (and consequent damage by) vehicles on the sidewalk surface. Also, during the day there is often no adequate corridor for pedestrian movement due to cars and trucks obstructing sidewalks.
- There are no clear rules on the provision of spaces in major traffic generators or new buildings.

Therefore, the main traffic management issues and challenges include the need to:

- reduce congestion bottlenecks/hotspots
- address traffic control system provision and operation
- reduce traffic accidents and address road safety issues
- address parking system and provision constraints

2.3.5 Existing Institutions and Capacity Issues/Challenges

The main institution and capacity issues and challenges in Greater Maputo include the need for:

- an improved metropolitan-level policy coordination mechanism
- a clearer demarcation of regulatory responsibilities in transport licensing across administrative boundaries

- capacity development of key organizations in Maputo City, Matola City, Boane City, and Marracuene District
- strengthening of higher education institutions in the provision of transport and traffic related courses

One of the major issues regarding urban transport development in Greater Maputo is the lack of effective coordination mechanisms between and among central, provincial, and municipal governments. At the local government level, the urban development plans have been prepared within respective administrative boundaries. As a result, there are few common policies or strategies for the metropolitan area development that are shared among all of the relevant organizations. Meanwhile various government agencies including central agencies are preparing and implementing urban transport projects without sufficient coordination with the local governments concerned. Many of those plans and projects, when implemented, will have major impacts on the future urban form of Greater Maputo. Thus, there is an urgent need to improve urban transport institutions and policy coordination mechanisms in the Maputo metropolitan area. The possibility of establishing a metropolitan level transport authority (commission) should be examined.

Under ProMaputo I and II, the Maputo Municipal Government undertook organizational reform and capacity development programs, which (among other achievements) improved land use planning capability. Infrastructure planning and implementation capacity have been relatively strong and a 2001 JICA urban transport project for Maputo assisted in the preparation of a road network development plan. In recent years, transport and traffic capabilities have also been improved with the creation of a department responsible for this sector by separating a unit from the department in charge of infrastructure in general. The traffic engineering division can perform many of the currently designed tasks with relatively well-qualified staff. However, the division has insufficient skills for preparing and implementing urban transport master plans. Also, the public transport division may have to be substantially strengthened in terms of number of staff and skills to perform its designed tasks.

Organizations in Matola City have weaker organizational capacities compared to the organizations with similar functions in Maputo City, due in part to a shortage of qualified staff. Boane and Marracuene also have a limited number of technical staff members and have to depend on the provincial government for their transport infrastructure development. Since there is an urgent need to improve metropolitan-wide policy coordination, the divisions with similar functions in the various municipalities and districts should cooperate with each other to develop policies, strategies, plans, and projects that extend across the metropolitan area. The capacity development programs mentioned above could also include strengthening of key divisions in these organizations.

Chapter 3 Development Framework

3.1 Introduction

This section covers the demographic framework which includes population growth, employment (workers) growth and enrolment (student) growth which is important to determine growth and changes in commute patterns. Furthermore, this section looks at economic growth (GDP/GRDP) and growth in vehicle ownership, which are also important for determining shifts in urban mobility and modality.

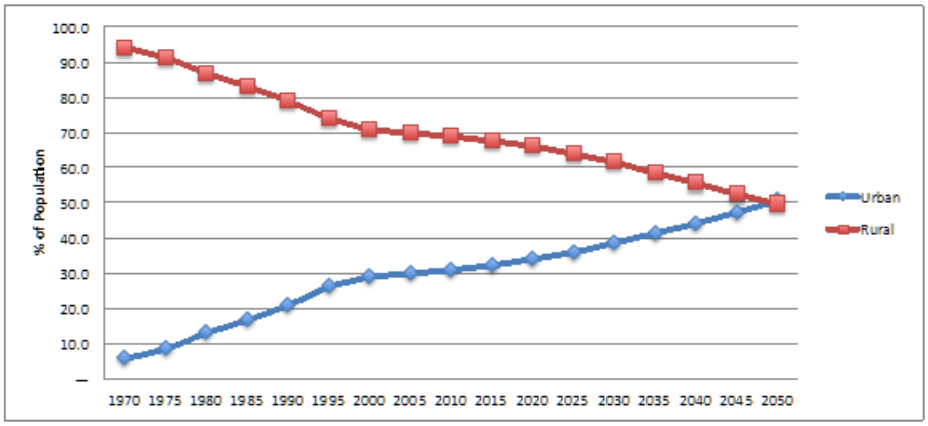
3.2 Demographic Framework

3.2.1 Population Projection

(1) Population Growth Trend

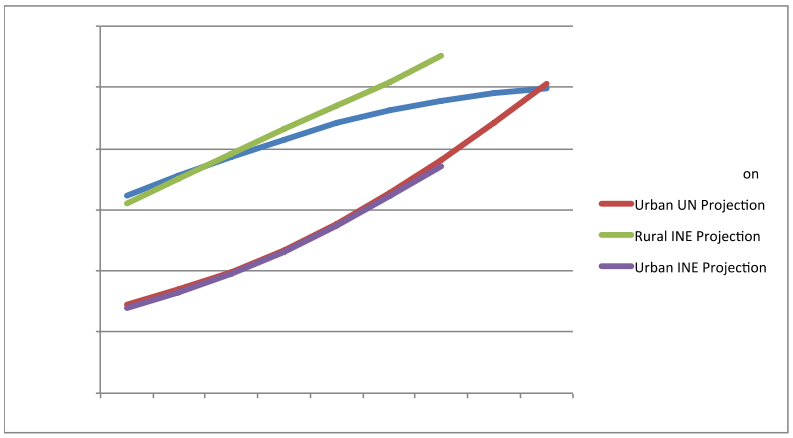
According to the United Nation's (UN) data, the urban population in Mozambique is projected to reach at 50% of the total population by 2050 as shown in Figure 3.1. This growing urbanization may result from a natural growth of population, economic development, and the development of urban-based economic activities. The population growth rate in the urban areas will gradually decrease to 1.2% in 2030 and to 0.3% in 2050 when the society matures as developed countries.

The population projection undertaken by the National Institute of Statistics (INE) has a different perspective regarding the rural population growth. INE projects the urban population will grow by 3.44% between 2010 and 2015 on average. The growth rate will gradually decrease to 2.5% by 2025, and 2.1% by 2040, which are the similar projection to that of the UN. However, the rural population will continue to grow at the same growth rate as the urban areas between 2020 and 2040. Figure 3.2 compares the projected population in rural and urban areas by the UN and INE between 2010 and 2050. The population in Mozambique is projected to attain 29.3 million by 2020, and 46.2 million by 2035.



Source: United Nations, World Urbanization Prospects, and the 2011 Revision.

Figure 3.1: Population Projection in Urban and Rural Area in Mozambique



Source: United Nations, World Urbanization Prospects, the 2011 Revision; Data from INE.

Figure 3.2: Urban and Rural Population in Mozambique Projected by UN and INE between 2010 and 2050

(2) Methodology

The population projection in the project area used to formulate the future traffic demand forecasts will be formulated based on the latest available and official population data of the 2007 Census, as well as the INE population projection up to 2040 for Maputo Municipality, Matola Municipality, Marracuene District Administration, and Boane City Administration. The population projection is distributed according to the administrative boundaries based on provinces, districts, bairros (urban areas), localities (rural areas), and villages (rural areas).

According to the interview with INE, the cohort based population projection up to 2040 by INE is based on the following assumptions: 1) birth rate and fertility rate; and 2) mortality rate, including infant mortality, and 3) urban and rural migration. INE's projection considers not only urban-rural migration but also migration between provinces and between districts, including population migration to the Greater Maputo Region. However, this projection is based on past trends up to 2007 and the 2007 Census, and does not consider land use pattern and the future urbanization plans. Therefore, the study adopts the future total population in the project area projected by INE as a base, but will change the population distribution according to land use patterns and urbanization plans.

In this study, the following planning horizon is considered:

1) Year 2012: This is the current and base year of the study
2) Year 2018: The target year for the short-term development plan of the Master Plan
3) Year 2025: The target year for the medium-term development plan of the Master Plan
4) Year 2035: The target year for the long-term development plan of the Master Plan

(3) Population Projection

The current and future population and population growth rate projected by INE are shown in Table 3.1 and Table 3.2. The population in the project area in 2012 accounts for 2.2 million, of which Maputo City consists of 54.8% of the total population. The population in Maputo City will reach at 1.5 million by 2035. The future concentration rate of population to Maputo City is expected to decline to 42.6% by 2035. On the other hand, the population in Matola Municipality is expected to grow from 0.8 million in 2012 to 1.7 million in 2035, overtaking the population of Maputo Municipality and becoming the most populous city in the Greater Maputo Region.

Marracuene and Boane are expected to grow more rapidly, increasing to triple the population between 2012 and 2035. The growth rates in Marracuene and Boane account for 7.4% and 6.1% in 2007 respectively, which is highest in the project area.

Table 3.1: Current and Future Population Projected by INE (2012–2035)

Municipality/ District	Census 2007		Current and Future Population Projected BY INE					
	Population	%	2012	%	2018	2025	2035	%
Maputo Municipality (Exc. Inhaca)	1,089,410	58.1	1,188,610	54.8	1,283,030	1,395,610	1,553,836	42.0
Matola Municipality	671,560	35.8	827,480	38.1	1,034,030	1,303,630	1,692,815	45.8
Marracuene	63,090	3.4	88,310	4.1	123,720	172,580	265,691	7.2
Boane	49,510	2.6	64,700	3.0	84,510	111,100	184,257	5.0
Total	1,873,570	100.0	2,169,090	100.0	2,525,300	2,982,920	3,696,599	100.0

Source: Data from INE

Note: The population in Marracuene and Boane in Table 3.1 shows the population in the project area, and does not include the total population in districts.

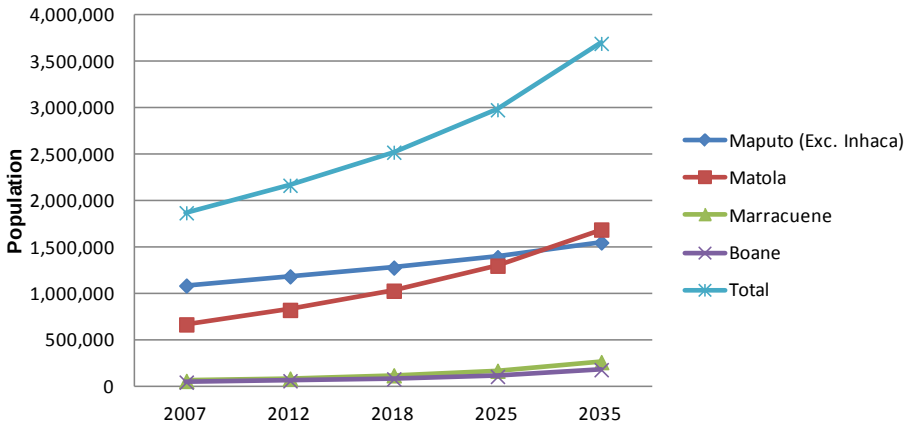
Table 3.2: Current and Future Population Growth Rate Projected by INE (2012–2035)

	Growth (97/07) (%)	Projected Population Growth Rate (%)			
Municipality/District	2007	2012	2018	2025	2035
Maputo Municipality (Exc. Inhaca)	1.3	1.8	1.3	1.2	1.1
Matola Municipality	4.7	4.3	3.8	3.4	2.7
Marracuene	7.4	7.0	5.8	4.9	4.0
Boane	6.1	5.5	4.6	4.0	3.5
Total Project Area	2.6–2.8*	3.0	2.6	2.4	2.1

Source: Data from INE

Note: *It is estimated that population in the total project area grew at 2.6% between 1997 and 2007, but this figure needs to be treated carefully since there was inconsistency in area data in Boane and Marracuene between 1997 and 2007. If all areas in Boane and Marracuene are included, the growth rate in the Greater Maputo Region between 1997 and 2007 is calculated at 2.8%.

Figure 3.3 shows the evolution of population growth rate in Maputo municipality, Matola Municipality, Marracuene, and Boane between 1997 and 2035, using INE data. In particular, this figure demonstrates the significance of the population increase in Matola Municipality.



Source: Data from INE

Figure 3.3: Population Growth by Municipality/District 2007 and 2035

The population above 6 years old in 2012 is required for a traffic demand forecast and is calculated by the following method:

Population (+6 years) in 2012 = Population (+5 years old) in 2012 − Population (0 year old) in 2007

The population of 0 year old in 2007 is expected to be the population of 5 years old by 2012, and thus the 0 year old population in 2007 is subtracted from the population of more than 5 years.

3.3 Employment and Enrolment

3.3.1 Employment (Job Distribution in 2035)

(1) Base Data

The *Ficheiro de Unidade Estatísticass* (FUE) in INE conducted an enterprise survey for all registered companies in 2009, which is the most updated and official data on the formal working population in Mozambique. FUE's enterprise data, classified by districts based on economic activity classification (*Classificação das Actividades Económicas*: CAE) for 2008, 2009, and 2010 is used for the estimation of current and future working population. The working population classified by CAE is integrated into three sectors of industry, i.e., primary sector of industry (agriculture, etc.), secondary sector of industry (transformed industry, extractive industry, etc), and tertiary sector of industry (services, commerce, transport, etc.).

The 2007 Census provides the working population data by economic activities at the residence-basis at the bairros/locality level. This data includes both formal and informal labor, and is used for calculating the working population in the informal sector. The workable population (15 to 64 years old) is available from the 2007 Census, and the future workable population is based on the projection by INE up to 2035. The 1997 Census is used to analyze a trend of working population at the province level.

(2) Employment Projection

It is assumed that the total working population is the economically active working population in the 2007 Census, including the formal and informal working population. The working population in the informal sector is estimated by subtracting the formal registered working population given by FUE from the total working population by the 2007 Census. It is assumed that primary (agriculture) sector workers work in the same district as their residence, and informal agriculture workers in the 2007 Census (residence) are distributed into the same district as to the working population at work place. In contrast, it is assumed that workers in the secondary (industrial) and tertiary (service) sectors often move beyond boundary of their residence, therefore, informal workers in those sectors are distributed according to the same weight as the formal workers by district.

A trend of working population growth rate between 1997 and 2007 and registered working population between 2008 and 2010 are used to estimate future employment. It is assumed that employment in Maputo Municipality will grow at the same growth rate of the formal sector as before (1.8%). On the other hand, employment in Matola Municipality and Boane is expected to grow at a higher growth rate than the average in Maputo Province, mainly due to the development of industrial and commercial activities along the Maputo Corridor. The participation rate in Maputo is expected to maintain constant, but the working population is expected to increase since female labor participation is anticipated gradually. It is assumed that Marracuene and Boane will maintain a high labor participation rate due to the dominance of the

agriculture sector. However, the percentage share of working population in the agriculture sector is anticipated to decline gradually as urbanization in these districts and the development of the industrial and service sectors are expected. Table 3.3 summarizes the projected employment growth rate in the project area between 2012 and 2035.

Table 3.3: Projected Employment Growth Rate (%) in Project Area (2012–2035)

Province/District	Growth rate in Census 97–07	Growth in FUE Data 08–10	2012	2018	2025	2035
Maputo Municipality	1.8*	1.4	2.5	2.0	2.0	1.5
Matola Municipality	3.7*	9.1	9.0	8.0	6.0	3.5
Marracuene	3.7*	−1.2	2.0	3.0	3.0	2.5
Boane	3.7*	1.9	3.5	5.0	5.0	3.5

Note: * indicates the growth rate of residence-based working population in Province
Source: JICA Project Team based on INE/FEU Data

In Maputo Municipality, industrial structure is expected to maintain constant, although small increase of the service sector is anticipated. In Matola Municipality and Boane, the industrial sector is expected to increase its share, based on the past trend and the expected development of industrial activities along the Maputo Corridor. The service sector is expected to grow in Matola Municipality, Boane, and Marracuene, which are led by the population increase, urbanization, and the subsequent growth in commercial activities. The development of the tourism sector in Marracuene (Macaneta) is expected, given the completion of the committed Incomati River Bridge.

The total future working population is calculated based on the residence-based workable population (ages 15–64). The working population at residence in the agriculture sector is distributed into the same district for work place while workers in the industrial and service sectors are expected to move beyond the residential area, and thus weighted based on the FUE's registered employment distribution in 2010. As the economy matures, the registered working population is expected to increase its share from 2025 onward. Table 3.4 shows the projected working population by residence.

Table 3.4: Estimated Working Population (by Residence)

	Estimated working population (by residence)			
	2012	2018	2025	2035
Maputo Municipality	391,690	441,106	499,778	574,324
Matola Municipality	257,842	345,533	446,093	599,512
Marracuene	42,574	58,703	79,887	107,362
Boane	48,180	62,742	80,912	103,574
Total	740,286	908,085	1,106,671	1,384,772

Source: JICA Project Team based on INE/FEU Data

Table 3.5 shows a summary of projected employment at work place. These numbers are used for the transport demand forecast to determine the destinations of commute for workers. The disaggregation of working population to transport demand forecast model analysis zones are made based on land use pattern.

Table 3.5: Estimated Working Population (at Work Place)

	Estimated working population (at work place)			
	2012	**2018**	**2025**	**2035**
Maputo Municipality	560,188	630,862	724,663	841,001
Matola Municipality	118,454	187,972	282,640	398,691
Marracuene	22,082	26,367	32,428	41,511
Boane	39,194	52,523	73,906	104,251
Total	739,918	897,725	1,113,637	1,385,455

Source: JICA Project Team based on INE/FEU Data

3.3.2 Enrolment

(1) Methodology

The current enrolment data at bairro/locality level in 2012 is provided by the Ministry of Education, Directory of Education in Maputo City and Maputo Province. INE provides the projected population data sorted by age groups up to 2040, which are used to estimate enrolment age groups. Residence-based student population data from the 2007 Census is used estimate the residence-based student population. The 1997 Census is used for a trend analysis.

(2) Enrolment Projection

Enrolment in the project area is estimated based on the enrolment rate to age groups, namely, 6–12 years old for primary schools, 13–17 years old for secondary schools, and 18–22 years old for higher education. Future enrolment is projected by a trend analysis using the 1997 and 2007 Census, and is based on gross enrolment rate (GER) and net enrolment rate (NER). GER is the gross number of students enrolled in each category of schools, while NER is calculated by applying the enrolled student population to each age group. GER in primary schools in the project area exceeds more than 100%, while the NER/GER ratio has been declining in primary and secondary schools between 1997 and 2007, implying that many over-age children participated in the education system.

Two methods are tested for a trend analysis. In the first method, the NER/GER in 2007 is applied for the projection of future enrolment in 2018–2035. This method results in over-estimation of enrolled students. The second method assumes that NER will increase gradually due to economic growth in the project area and a logistic trend is applied to estimate the future net enrolment rate. The latter method is found appropriate to estimate the future enrolment and the future NER/GER is calculated by a trend analysis between 1997 and 2012, applying a logistic estimation.

In Mozambique, technical schools consist of 1) elementary level (11–12 years old), 2) basic level (13–15 years old), 3) medium level (16–18 years old), and higher level (more than 18 years old). While higher technical institutes are categorized into higher education, other technical schools are normally joined into the category of technical schools. The study uses a trend of enrolment in medium technical schools in Maputo City for the projection of future enrolment. The following linear regression model is applied for calculating the future enrolment in technical schools:

$$E = 478.82X - 955913$$

Where E = Enrolment in technical school in Maputo City, X = year

The same trend of growth rate is applied for estimating enrolment in technical schools in Maputo Province (Matola, Marracuene, and Boane).

Table 3.6 shows a summary of the projected student population. The disaggregation of enrolment to transport demand forecast model analysis zones are made based on land use pattern.

Table 3.6: Estimated Student Population

	Estimated student population			
	2012	**2018**	**2025**	**2035**
Maputo Municipality	359,141	385,237	427,683	422,378
Matola Municipality	238,124	302,676	404,112	493,341
Marracuene	31,429	46,993	68,842	95,864
Boane	32,882	45,954	62,580	83,186
Total	661,576	780,859	963,217	1,094,769

Source: JICA Project Team based on Ministry of Education and INE Data

3.4 Expected Economic Growth

3.4.1 GDP/GRDP

(1) Base Data

GDP and GRDP data is necessary for the traffic demand forecast and projection of vehicle ownership in future. INE provides the official statistical data on GDP and GRDP by province up to 2009. The Ministry of Planning and Development (MPD) is responsible for the estimation and projection of GDP in Mozambique, which is available between 2010 and 2025. However, the projection for the long-term economic growth is not available and economic growth for the future is examined in coordination with MPD. The projection of GRDP growth rate is also not available, hence the study team consulted with MPD and relevant stakeholders regarding the economic growth in Maputo City and Maputo Province.

The latest GDP structure data by industry is available from INE and is used for the projection of GDP structure by industry. The projection of GDP structure by industry is provided by MPD up to 2013 and will be applied for this study. There is no data on GRDP structure by industry in Maputo City and Maputo Province, and thus a national level projection of GDP structure by industry will be performed.

(2) GDP/GRDP Projection

Table 3.7 shows a detailed breakdown of the GDP/GRDP/GRDP per capita projection between 2012 and 2035 for Maputo Municipality and Maputo Province (including Matola Municipality, Boane City, and Marracuene District) are shown.

Table 3.7: GDP/GRDP Growth Projection (2012–2035)

	Unit	2009 (Actual)	2010 (Est.)	2011 (Est.)	2012 (Proj.)	2018 (Proj.)	2025 (Proj.)	2035 (Proj.)
Mozambique								
Population		21,802,866	22,416,881	23,049,621	23,700,720	27,843,930	33,165,000	41,553,730
Real GDP (at 2003 constant price)	Mil. Mt	171,873	184,050	197,525	212,360	337,920	597,610	1,083,190
Real GDP (at 2009 constant price)	Mil. Mt	266,213	285,114	305,927	328,870	523,320	925,490	1,677,490
Real GDP growth rate	%	6.4%	7.1%	7.3%	7.5%	8.2%	8.6%	5.1%
GDP per capita (at 2009 constant price)	Mt	12,918	12,719	13,273	13,880	18,800	27,910	40,370
GDP per capital (at 2009 constant price)	USD	457	385	491	500	670	1,000	1,440
GDP per capital growth rate (real)	%	4.0%	4.2%	4.4%	4.5%	5.4%	6.0%	2.8%
Maputo Municipality								
Population		1,145,307	1,161,833	1,178,116	1,194,120	1,288,720	1,401,480	1,565,770
Real GDP (at 2003 constant price)	Mil. Mt	31,696	33,693	35,917	38,400	58,000	89,280	138,630
Real GDP (at 2009 constant price)	Mil. Mt	47,379	50,364	53,688	57,390	86,700	133,450	207,220
Real GDP growth rate	%	6.1%	6.3%	6.6%	6.9%	7.0%	5.5%	4.0%
GDP per capita (at 2009 constant price)	Mt	47,379	43,348	45,571	48,060	67,270	95,220	132,350
GDP per capita (at 2009 constant price)	USD	1,549	1,314	1,687	1,720	2,400	3,400	4,720
GDP per capital growth rate (real)	%	3.9%	4.8%	5.1%	5.5%	5.7%	4.3%	2.9%
Maputo Province								
Population		1,329,395	1,385,604	1,444,624	1,506,440	1,937,920	2,588,340	3,804,760
Real GDP (at 2003 constant price)	Mil. Mt	22,950	24,442	26,153	28,040	43,470	74,700	135,410
Real GDP (at 2009 constant price)	Mil. Mt	35,081	37,361	39,976	42,860	67,190	115,470	209,290
Real GDP growth rate	%	5.9%	6.5%	7.0%	7.2%	7.8%	7.8%	5.1%
GDP per capita (at 2009 constant price)	Mt	26,389	26,964	27,673	28,450	34,670	44,610	55,010
GDP per capita (at 2009 constant price)	USD	988	817	1,024	1,020	1,240	1,590	1,960
GDP per capital growth rate (real)	%	3.5%	2.2%	2.6%	2.8%	3.4%	3.5%	1.4%

Source: Actual data from INE, estimation and projection data between 2010 and 2025 from MPD, and JICA Project Team

Note: Exchange rates between 2009 and 2012 are based on the data from Statistical Year Book 2010 by INE and the data from Bank of Mozambique. Thereafter, the exchange rate in 2012 (July) is applied.

For the purpose of the transport demand forecast modeling, the GDP/GRDP growth projection for Greater Maputo summarized in Table 3.8 is used.

Table 3.8: GDP/GRDP Growth Projection (2012–2035)

	2012	2035	2035/2012	Growth rate
Population (1,000)	2,169	3,697	1.7	2.2%
GRDP (mil MT)	80,820	325,091	4.0	6.0%
GRDP/Capita (USD)	1,379	3,137	2.3	3.5%
Annual Income (USD)	683	1,554	2.3	3.5%

Source: JICA Project Team

(3) GDP Structure by Industry

The extractive sector in Mozambique is expected to grow rapidly in the medium term. Mozambique's natural resource reserves (coal, natural gas, and mineral sands) have not been fully explored. According to the preliminary estimate of IMF, the mega projects in Mozambique can directly contribute up to 18% of total value added by 2016, of which the coal extraction may consist of around 9% of the total GDP.

The tertiary (service) sector has grown at an average rate of 7% in the past decade, and is expected to continue to grow at a similar growth rate mainly due to the gradual urbanization as well as the development of the transport sector necessary to transport natural resources along the corridors. At the same time, however, the boost of the extractive sector may decelerate the growth in the service sector. Accordingly, the percentage structure of the service sector in total value added may not change considerably in the years to come.

The primary industry is expected to decline the percentage share of GDP, mainly due to the gradual population movement between rural-urban areas in Mozambique and growth in the other sectors.

These potential trends were taken into account for the GDP projection by industry until 2025. From 2026 on, since a great deal of uncertainty is involved in the projection of economic structure, it is assumed for projection purposes that the GDP structure by industry in 2026–2035 will remain the same as that during 2021–2025.

Table 3.9 and Table 3.10 summarize the current and future GDP by industry in Mozambique between 2009 and 2035.

Table 3.9: Percentage Structure of GDP by Industry in Mozambique (2009–2035) (%)

		Secondary Industry					
	Primary Industry	Total	Extractive Industry	Manufac-turing	Electricity/ Water	Construc-tion	Tertiary Industry
2009	25.2	22.3	1.1	12.8	4.9	3.4	43.6
2010	25.1	21.8	1.2	12.4	4.8	3.4	44.1
2011	24.9	21.3	1.3	11.9	4.8	3.3	44.0
2012	24.3	21.8	1.9	11.5	5.1	3.3	48.1
2013	23.7	22.3	3.0	11.0	5.0	3.3	44.5
2014	22.8	23.2	5.0	10.5	4.5	3.2	44.7
2015	20.8	25.4	8.0	10.2	4.0	3.2	44.5
2016	20.4	25.6	9.0	10.0	3.5	3.1	44.7
2017	17.9	28.3	12.0	10.0	3.2	3.1	44.5
2018–2020*	15.7	30.7	15.0	9.8	2.9	3.0	44.3
2021–2025*	14.7	31.6	16.0	9.8	2.8	3.0	44.4
2026–2030*	14.7	31.6	16.0	9.8	2.8	3.0	44.4
2031–2035*	14.7	31.6	16.0	9.8	2.8	3.0	44.4

Source: Actual data from INE (2009), estimation and projection by MPD (2010–2013), and JICA Project Team
Note: *indicate the average figures.

Table 3.10: GDP by Industry in Mozambique (2009–2035, Constant Price in 2003) (Million MT)

		Secondary Sector of Industry					
	Primary Industry	Total	Extractive Ind.	Manufac-turing	Electricity/ Water	Construc-tion	Tertiary Industry
2009	43,252	38,170	1,910	21,910	8,420	5,920	74,450
2010	46,130	40,170	2,150	22,890	8,900	6,240	80,510
2011	49,690	42,090	2,500	23,570	9,490	6,530	85,250
2012	51,600	46,230	4,090	24,390	10,720	7,030	102,140
2013	54,550	51,330	7,010	25,320	11,570	7,590	102,370
2014	56,520	57,570	12,410	26,050	11,170	7,940	110,970
2015	55,730	67,940	21,400	27,280	10,700	8,560	118,940
2016	58,850	73,890	25,980	28,860	10,100	8,950	129,040
2017	56,040	88,380	37,470	31,230	9,990	9,680	138,830
2018–2020*	57,270	112,520	55,150	35,900	10,480	10,990	162,500
2021–2025*	74,990	161,200	81,620	49,990	14,280	15,300	226,490
2026–2030*	107,800	231,740	117,340	71,870	20,530	22,000	325,610
2031–2035*	143,990	309,530	156,720	95,990	27,430	29,390	434,900

Source: Actual data in 2009 from INE, estimation and projection in 2010–2013 by MPD, and JICA Project Team
Note: * indicates the average figures.

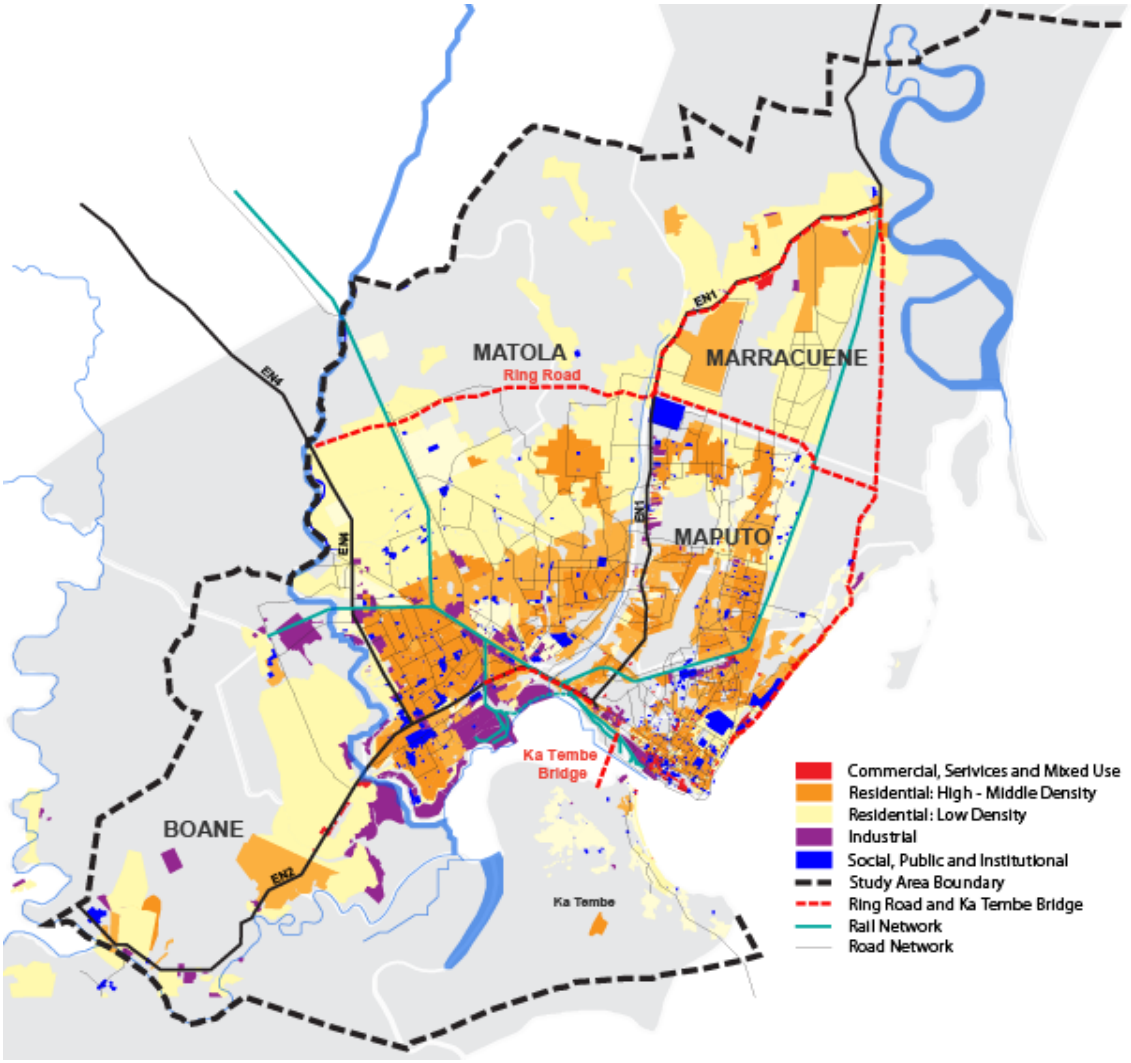
Chapter 4 Alternative Land Use Development Patterns

4.1 Introduction

This section examines urban planning and land use trends to establish the urban development scenarios for the transport demand forecast modeling.

4.2 Existing Land Use and Development Trends

Figure 4.1 shows the existing land use pattern compiled by the JICA Project Team based on existing structure plans, geographic information system (GIS) remote sensing, satellite imagery, and interviews with urban planning officials. Much of the existing land use map for Maputo Municipality and Matola City is based on the *Plano de Estrutura Urbana do Município de Maputo* (PEUMM – Maputo City Urban Structure Plan 2008) and the *Plano de Estrutura Urbana da Cidade da Matola* (PEUCM – Matola City Urban Structure Plan 2010). The maps have been updated by overlaying satellite imagery and information from interviews to track developments in recent years. Although Boane City and Marracuene District are developing an existing land use plan, due to the schedule of this project, existing land use in these two districts were compiled based on GIS remote sensing, satellite imagery, and information from interviews.



Source: JICA Project Team

Figure 4.1: Existing Land Use

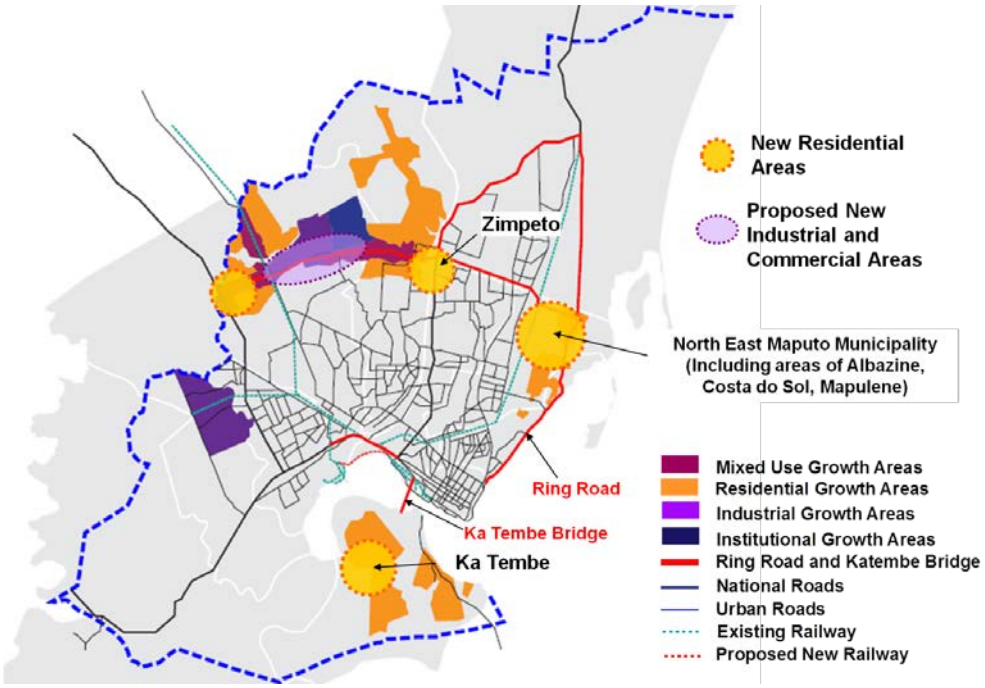
Based on the land use pattern shown above, the 2011 socio-economic indicators (such as population, number of workers, and number of students) were spatially distributed to the C-zone[1] level for the purpose of the transport modeling and analysis. Table 4.1 shows the area in hectares, 2011 night time population, and average density (persons/hectares) by municipality/ district.

Table 4.1: Current Area, Night Time Population and Average Density by City/District

Region	Area (ha)	2012 Population	Average Density (persons/ha)
Maputo	26,961	1,188,612	44
Matola	38,079	827,475	22
Marracuene	30,490	88,309	3
Boane	25,238	64,698	3
TOTAL	120,767	2,169,094	18
Highest Density Bairro (Maputo–Maxaquene B)	105	29,944	284

Source: JICA Project Team

Based on information collected from existing urban structure plans and interviews with stakeholders including planning officers of the municipalities and districts, national government agencies, donors, developers, and consultants, the JICA Project Team identified areas of urbanization plans, growth centers (Figure 4.2), and committed development projects (Table 4.2) in Greater Maputo.



Source: JICA Project Team based on PEUMM, PEUCM, and interviews with City, District, National Government Agencies, as well as with consultants, in June 2012

Figure 4.2: Growth Centers

[1] Two zoning systems were used in this study:

- B-zones: This zoning level is adequate to examine the arterial traffic network. B-zones were set using the "bairro", the smallest unit used for the population census data. Some areas of the suburbs were zoned in a way that consolidated a few bairros. The number of zones within the study area was 40.
- C-Zones: This zoning level divided the urban center into smaller sections to assess the detailed forecast and planning. Bairros were broken down into smaller sections to accommodate the road network in the city center. The number of zones within the study area was 170.

Table 4.2: Planned and Committed Development Projects

Name	City/ District	No. of Households Planned (Units)	Size (ha)	Expected Budget	Status	Developer/ Company
Dream Town Intaka	Matola City	5,000	300	MZM 12 billion (about USD 444 million equivalent)	Under Construction	Henan Gouji Industry and Development (China)
Zimtava	Marracuene District	Not yet determined	200	Not Available	Under Discussion	(Spanish Developer)
Possuane (Low Cost Housing)	Marracuene District	1,500	400	Not Available	Under Discussion	
Marracuene Land Use Plan	Marracuene District	–	–	–	Under Progress	DHV
Boane Land Use Plan	Boane City				Under Progress	
Piccoco 2	Boane City	8,000	400	Not Available	Under Discussion	Gamont Development (South Africa)
Mulotane (Low Cost Housing)	Boane City	Not Available	Not Available	Funding Approved	Under Discussion	(Portuguese-French Developer)
KaTembe (Within Maputo Sul/ Betar Plan)	Maputo City	Not Available	200–300	–	Under Discussion	–
Cidadela de Matola Project	Matola City	Mixed Use (Shopping Center, hotel, etc.)	46,000 m^2	Public Investment Corporation (South African funded) will invest USD 200 million	Under Discussion	Consortium of SIF (Mozambique) and McCormick Property Development Company (South Africa)

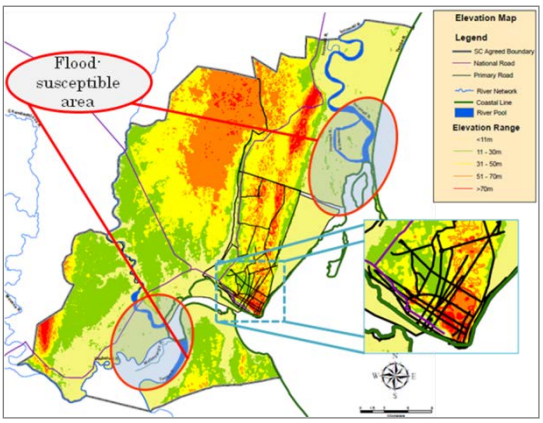
Source: JICA Project Team based on Interviews with City, District, and National Government Agencies, as well as with consultants, in June 2012

4.3 Physical Constraints for Urbanization – Natural Environment

4.3.1 Flood Susceptibility

In terms of physical constraints, flood-susceptible areas (Figure 4.3) with high risks of being flooded due to the geographic condition and low natural drainage, were identified. Furthermore, coastal wetlands (mangroves) on the eastern coast of Greater Maputo were identified (Figure 4.4). The wetland performs important ecological functions such as drainage, rainwater reception, and dissipation.[2] Acknowledging its ecological importance, the City of Maputo made a decision in October 2012 to protect this area and develop it as a natural park. Urban development in these areas should be avoided or carefully planned.

[2] Zoning and Protection Study of Costa do Sol Mangrove/Wetland Final Report, 2011



Source: Prepared by JICA Project Team (Based on ASTER DEM 90 m)

Figure 4.3: Topographical Map of Greater Maputo

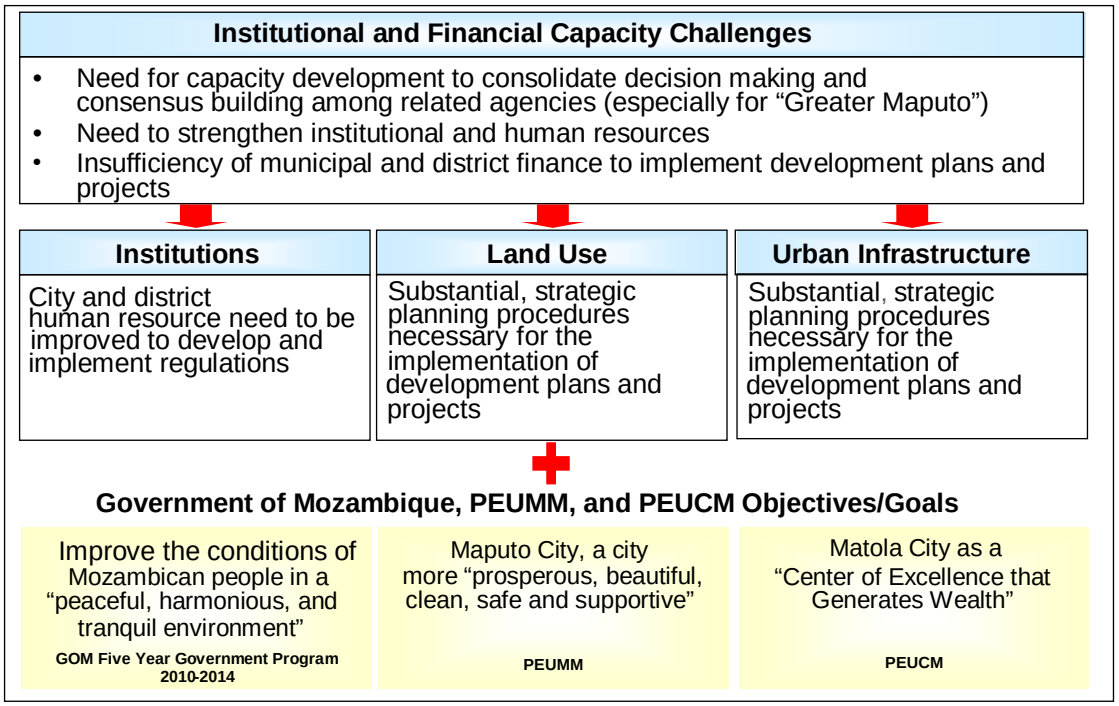
Source: Department of Environment, City of Maputo

Figure 4.4: Costa do Sol Mangrove Conservation Area

4.4 Urban Development Visions, Goals, and Strategies

As described earlier, the urban structure plan that currently exists is one for Maputo City and another for Matola City, and there is no effective urban structure plan targeting the entire area of Greater Maputo. It was therefore necessary to set out urban development strategies and scenarios for Greater Maputo as one of the bases for urban transport master planning in this study.

Through working groups and individual consultancy meetings with planning officials and consultants, urban planning and development challenges in Greater Maputo were identified by stakeholders as summarized in Figure 4.5.



Source: JICA Project Team

Figure 4.5: Urban Planning and Development Challenges

Based on existing objectives and goals from the Government of Mozambique Five Year Government Program, PEUMM, and PEUCM, potential urban development vision statements were developed as follows:

Vision 1: Greater Maputo: "*The City Bridging the Old and New*";
Vision 2: Greater Maputo as a "*Socially and Environmentally Sustainable International Gateway Capital*"; and
Vision 3: Greater Maputo as a "*Dynamic and Vibrant Capital of Mozambique*".

The three potential urban development vision statements were examined through a Strategic Environmental Assessment (SEA) process as explained in Section 4.5, and the selected development vision statement is summarized in Figure 4.6.

Greater Maputo as a Urban Development Vision:
"Socially and Environmentally Sustainable International Gateway Capital"

The Urban Development Vision in Detail:

Socially Sustainable Capital	Environmentally Sustainable Capital	International Gateway Capital
• Socially inclusive urban structure and infrastructure accessible to all inhabitants (including low-income, foreigners, disabled, elders, and children) • Economically inclusive urban industrial structure for sustainable economic growth including employment generation and poverty reduction	• Urban Structure that allows for the protection of inhabitants from natural disasters and unhealthy living conditions • Protection and preservation of natural conditions (green space and coastal areas) for future generations • Environmentally sustainable urban infrastructure accessible to all inhabitants	• Maximize benefits of Maputo's position as the transit city with access to ports, industrial zones and regional markets • Conservation of historical and cultural heritage for enhanced urban character and identity • Socially and environmentally sustainable economic growth and development

Source: JICA Project Team

Figure 4.6: Urban Development Vision for Greater Maputo

To achieve the urban development vision for Greater Maputo, the following development strategies were agreed upon.

(1) Multiple-Core Urban Structure

Strategy:

1. Shift of functions from the central business district (CBD) to poly-centers to alleviate traffic congestion
2. Development of polycentric commercial and business districts to decentralize economic activity
3. Plan appropriate local urbanization plans and strictly implement land use and zoning regulations to ensure that new informal developments do not occur. Furthermore, strengthen coordination and communication between the private and public sector to ensure commercial and business development are aligned with urban plans. Conduct public meetings to disseminate information of updated plans and on-going projects to enhance private sector and citizen participation and ownership. Formalization and densification of housing development around poly-centers and/or public transport axes to decrease the costs of urban infrastructure

Outputs:

1. Lower and affordable commuting costs
2. Decentralized services accessible to peri-urban[3] inhabitants

[3] "Peri-urban" refers to areas where dispersed urban growth has occurred in rural surrounding of cities (i.e. urban sprawl) due to pressures from growing urban centers. Often times, land uses of such areas are characterized by both urban and rural socio-economic activities. These areas are distinctly different from suburban areas, which are mainly mono-functional (i.e. residential) areas planned and developed proximal to the urban center. In the case of Greater

3. Controlled and planned urban growth containing sprawl
4. Densified and compact land use leading to lower urban infrastructure costs

(2) Sustainable Economic Development

Strategy:

1. Utilization of existing assets such as Maputo/Matola Ports, Maputo Economic Corridor, and Free Economic Zones (FEZs)
2. Strategic upgrading and provision of urban infrastructure to enhance private sector investments
3. Diversification of sustainable economic structure for employment generation

Outputs:

1. Economic diversification and decentralization allowing for more revenue and greater budget for investments in urban infrastructure
2. Investments in urban infrastructure that will lead to increased private sector investments and land values
3. Minimization of budget and capacity discrepancies of local governments

(3) International Capital for Culture

Strategy:

1. Enhance tourism and commercial development through the utilization of historical and cultural assets
2. Protection and preservation of green spaces, coastal areas, and natural disaster zones
3. Provision of urban amenities for sports, recreation, and parks
4. Improvement of urban health, sanitation, and safety

Outputs:

1. Urban structure with harmonized cultural, historic, and new buildings and infrastructure
2. Clean, healthy, and safe urban environment
3. Inclusive urban structure for all, including elders, children, disabled, foreigners, and lower-income households

4.5 SEA Consideration of Strategies

In this project, the SEA considerations were applied in two stages. The first stage was development of future vision and the second stage was alternative transport development scenarios.

Three potential urban development vision statements were developed as follows.

Vision 1: Greater Maputo: *"The City Bridging the Old and New"*
Vision 2: Greater Maputo as a "*Socially and Environmentally Sustainable International Gateway Capital*"
Vision 3: Greater Maputo as a "*Dynamic and Vibrant Capital of Mozambique*"

These statements were evaluated and compared in view of the following environmental and social viewpoints.

Maputo, peri-urban areas refer to the formal and/or informal areas in Boane, Marracuene and northern Matola that have both urban and rural characteristics due to pressures from urban growth in Maputo Municipality.

- Area-wide assessment
- Economic impacts
- Social impacts
- Environmental impacts
- Public involvement

The results of the evaluation are summarized in Table 4.3. Vision 2 marked the highest score and therefore was selected as the development vision of the Greater Maputo Area.

Table 4.3: Examination of Urban Development Visions by SEA

Impacts	Details	Vision 1	Vision 2	Vision 3
Area - wide	The vision considers overall Greater Maputo area	✓	✓	✓
	The vision considers not only Greater Maputo and other surrounding areas			✓
Economic	The vision includes economic perspectives		✓	✓
Social	The vision implies benefit for all citizens, including vulnerable people		✓	
	The vision encourages preservation of cultural heritage	✓	✓	
	The vision attempts to avoid or minimize negative social impacts caused by urban development		✓	
Environmental	The vision envisages improvement of city landscape	✓	✓	✓
	The vision considers sustainable development of Greater Maputo	✓	✓	✓
	The vision attempts to minimize negative environmental impacts caused by urban development		✓	
Qualitative assessment (total number of ticks)		**4**	**8**	**5**

Source: JICA Project Team

4.6 Urban Development Patterns (Existing Trend, Poly-Centric, Compact Corridor)

4.6.1 Context

The formulation of urban development scenarios for Greater Maputo dates back to 1985. Although it is outdated and no longer effective, the Structure Plan of 1985 for Maputo and Matola hypothesizes the following urban expansion pattern for the Maputo metropolitan area:

1. Uncontrolled Development (status quo);
2. Concentric Expansion;
3. Linear Expansion.

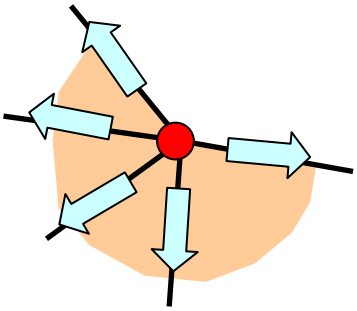
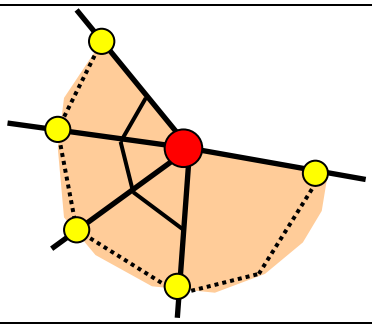
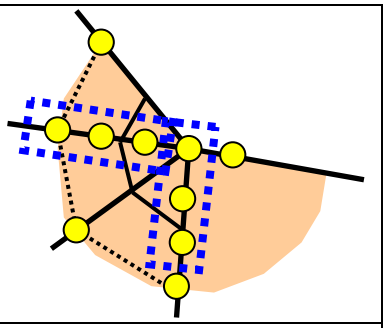
The 1985 plan addresses the importance of avoiding alternative 1 (uncontrolled development), and indicates that alternative 2 (concentric expansion) is unfeasible due to the lack of resources for its implementation. The plan suggests alternative 3 (Linear Expansion) as a feasible development pattern for the metropolitan area, with both long and short term benefits.[4]

[4] PEUMM

A quarter of a century after the 1985 Structure Plan, Greater Maputo has grown significantly in population as well as socio-economically. However, the concern addressed in the 1985 Structure Plan has not yet been appropriately resolved. With the consideration of the socio-economic framework (detailed in Technical Report A), the current urban and land use conditions (Technical Report B), the plans and solutions explored in preceding structure plans (Technical Report C), the following section proposes urban development patterns and scenarios fit for the urban challenges of Greater Maputo.

4.6.2 Proposed Alternative Urban Development Scenarios

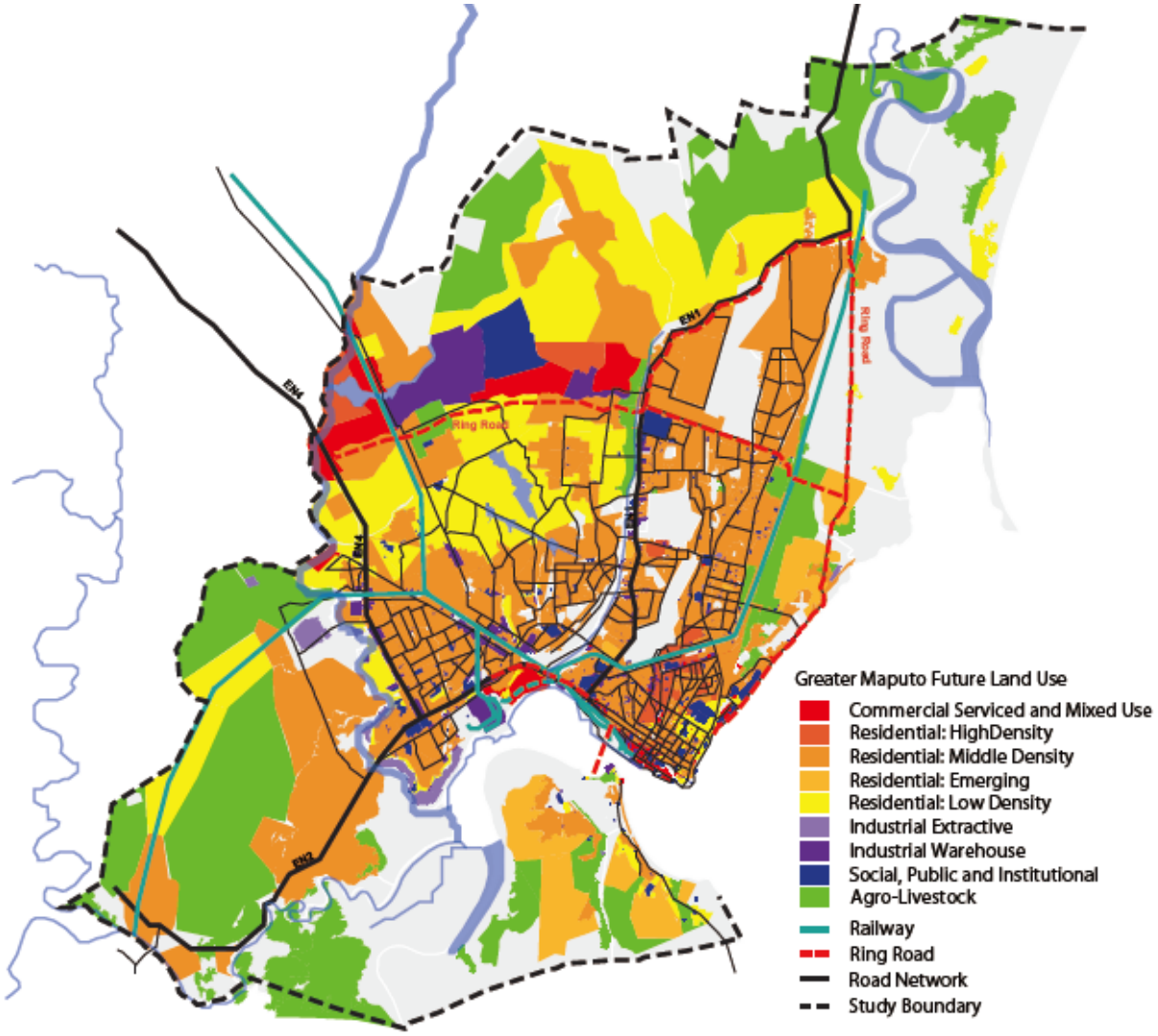
As a result of the examination summarized in this sub-section, three alternative urban development scenarios have been considered as shown in Figure 4.7. The process that led to these scenarios is described below.

			
Scenario	A. Trend Growth: Monocentric Radial Development (Unplanned Growth)	B. Polycentric Satellite Center Development Pattern	C. Compact Corridor Development
Land Use Characteristics	Existing trend, uncontrolled urban sprawl, low-density development	Decentralized development, lower level of concentration in CBD	High-density development along mass transit corridors, decentralized population

Source: JICA Project Team

Figure 4.7: Urban Development Scenarios for Greater Maputo 2035

As explained in Section 4.2, information on development trends from the structure plans of PEUMM and PEUCM, urbanization plans, growth centers and interviews regarding planned and committed projects have been collected, and a base (trend growth pattern or Scenario A) land use plan for 2035 has been created as shown in Figure 4.8.



Source: JICA Project Team

Figure 4.8: Base Land Use Map of Greater Maputo 2035

Based on the land use pattern shown above, the 2035 trend growth (Scenario A) socio-economic indicators were spatially distributed to the C-zone level (with the methodology further explained in Section 4.7) for the purposes of the transport modeling and analysis. Table 4.4 shows the area, 2035 tend growth population and average density (persons/hectares) by municipality/district and its change from 2011.

Table 4.4: 2035 Trend Growth Population, Average Density, and Change from 2011 by City/District

Region	Area (HA)	2011		2035 Scenario A (Trend Growth)		Change	
		Population	Avg. Density (persons/HA)	Population	Avg. Density (persons/HA)	Population	Avg. Density (persons/HA)
Maputo	26,961	1,188,612	44	1,553,836	58	365,224	14
Matola	38,079	827,475	22	1,692,815	44	865,340	23
Marracuene	30,490	88,309	3	265,691	9	177,382	6
Boane	25,238	64,698	3	184,257	7	119,559	5
TOTAL	120,767	2,169,094	18	3,696,599	31	1,527,505	13

Source: JICA Project Team

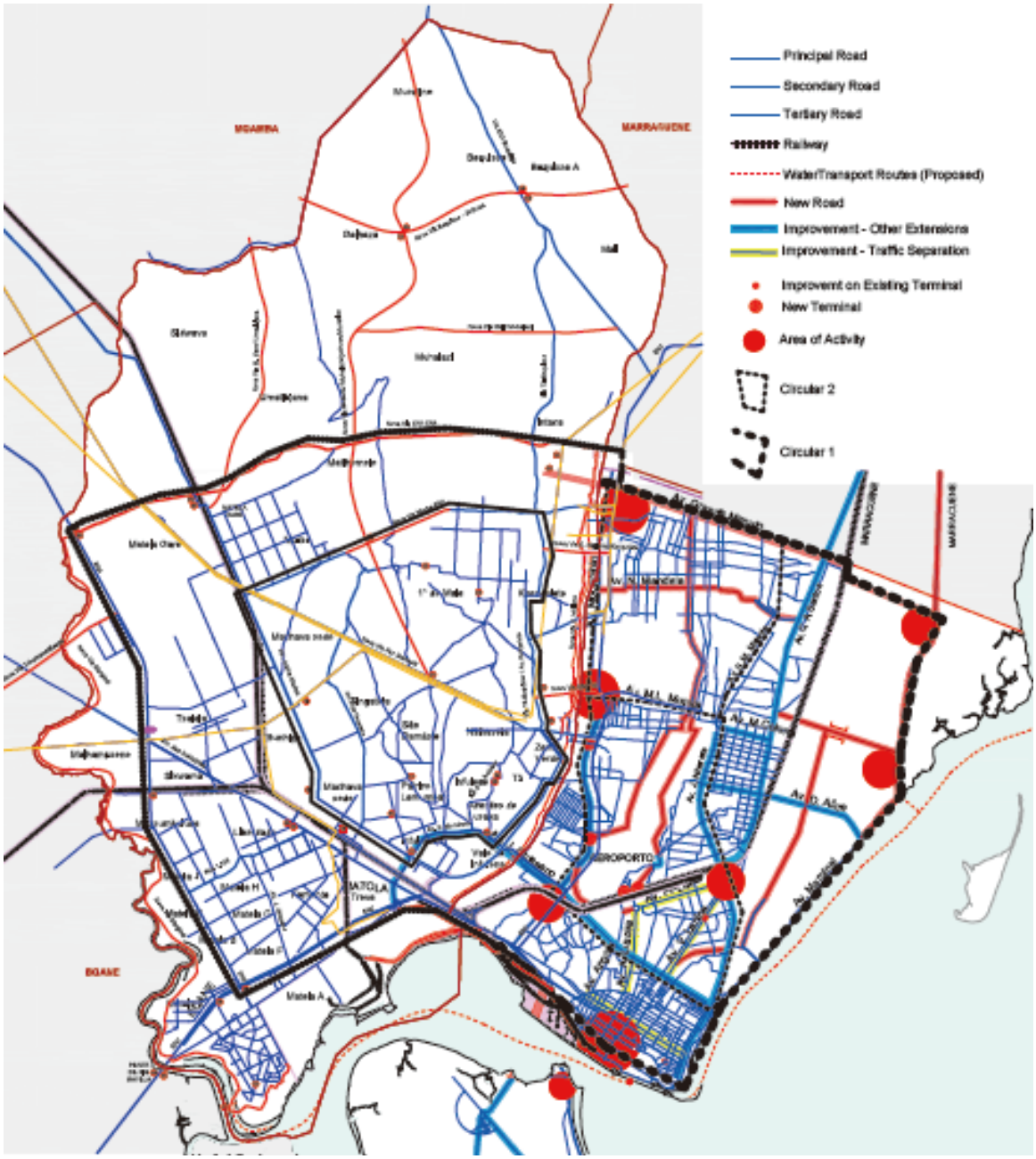
Furthermore, through a thorough discussion with stakeholders, development trends toward polycentric urban structure were geo-spatially identified as shown in Figure 4.2 (details of the identified potential poly-centers are further explained in Technical Report D). These development trends include various housing, commercial, and industrial projects proposed, committed and/or under construction both in the private and public sectors. The proposed second scenario (Polycentric Satellite Center Development Pattern or Scenario B) can be considered half way under implementation. While the geo-spatial positioning of potential "poly-centers" or socio-economic urban nodes are suggested in both the PEUMM and PEUCM, development has been private sector driven, or market driven (naturally developing in locations with substantial local demand and appropriate accessibility). Scenario B therefore is half based on natural tendencies to consolidate socio-economic activities to efficiently serve a greater population, but it also must be an outcome coordinated with upper level policies and planning (including major public investment in the transport capacity improvement along corridors linking various poly-centers) so that developments are indeed sustainable, comprehensive and inclusive.

The final development scenario (Compact Corridor Development) builds on the structure of the Polycentric Development Scenario, but considers the possibility of further enhanced transport and commute corridors beyond those for Scenario B. In the Polycentric Development Scenario, local communities benefit from accessibility to consolidated socio-economic nodes located in various strategic locations around the city based predominantly on market supply and demand. However, connection and network between various poly-centers are not strong enough due to lack of sufficient transport services. The Compact Corridor Development scenario geo-spatially identifies optimal transport corridors based on existing and planned transport infrastructure which would connect key neighborhoods and poly-centers. It is considered that the Compact Corridor Development requires even greater transport investment than Scenario B especially in the mass transit development along major corridors in Greater Maputo.

The concept of polycentric satellite center development (centers of activity) and the need to enhance connectivity between these centers of activity (compact corridor development) is a concept explored in the context of urban mobility in both the PEUMM and PEUCM as shown in Figure 4.9. In recent years, there is a strong understanding of negative implications of Scenario A, and much improvement in urban structure and formalization can be seen through the continued efforts of the cities and assistance through PROMAPUTO. Furthermore, private sector led urban development can be seen around socio-economic activity centers in strategic locations with accessibility to existing, planned, committed or under construction transport infrastructure projects (such as the intersection of the Ring Road and N1) as suggested in Scenario B.

However, while the need to aim for Scenario C is essential to the future of urban mobility, structure and function, there are various challenges that must be addressed and resolved. Most importantly, the issues of urban planning and urban transport extend beyond the geo-political boundaries of the cities/district, and cooperation and coordination is essential. A comprehensive urban planning and development master plan with consideration of urban transport and mobility should be developed for Greater Maputo.

In Chapter 5, transport network options for Greater Maputo are proposed, which correspond to these alternative urban development scenarios. A comparison of the proposed transport network options is then made in Chapter 6, leading to a recommendation of a preferred transport network, which is taken forward for setting out Master Plan projects and programs.

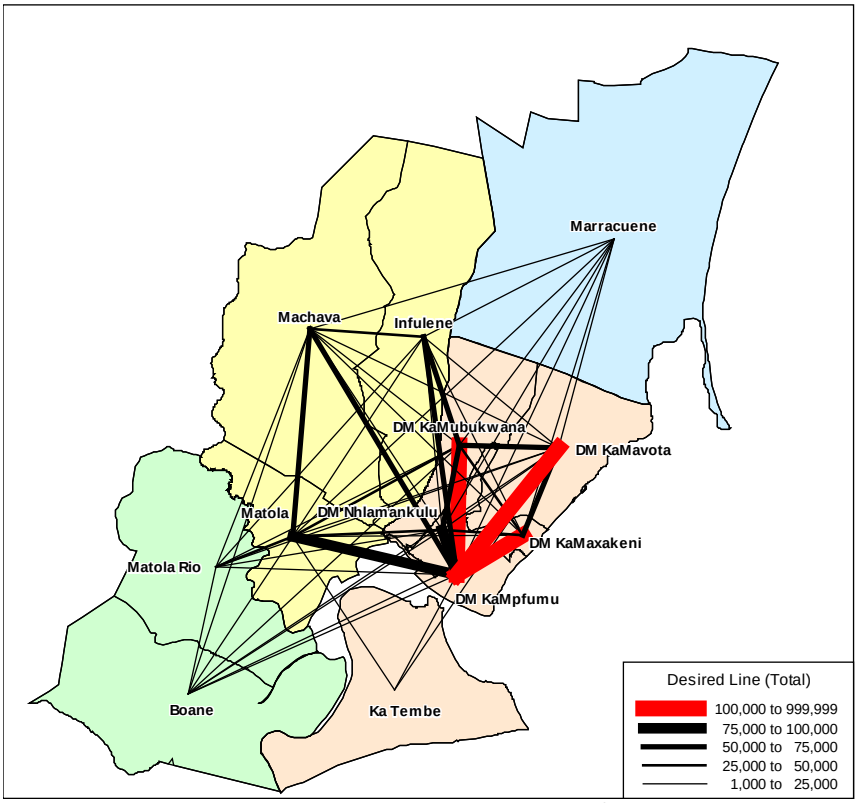


Source: Consolidated based on PEUMM and PEUCM

Figure 4.9: Urban Mobility Plan as Mentioned in PEUMM and PEUCM

4.6.3 Existing Transport Conditions and Urban Development Scenarios

The existing travel patterns indicate that several major corridors indeed have been developed in Greater Maputo as shown in Figure 4.10 and Table 4.5. These corridors include Maputo CBD–Zimpeto area and Maputo CBD–northeastern Maputo (i.e., the North-South Transport Axis), and Maputo CBD–Matola/Machava (i.e., the East-West Transport Axis).



Note: The lines are drawn between geographical centers of the zones that may not correspond to population centers. For example, the population center of Machava District is located more closely to Matola District.
Source: JICA Project Team

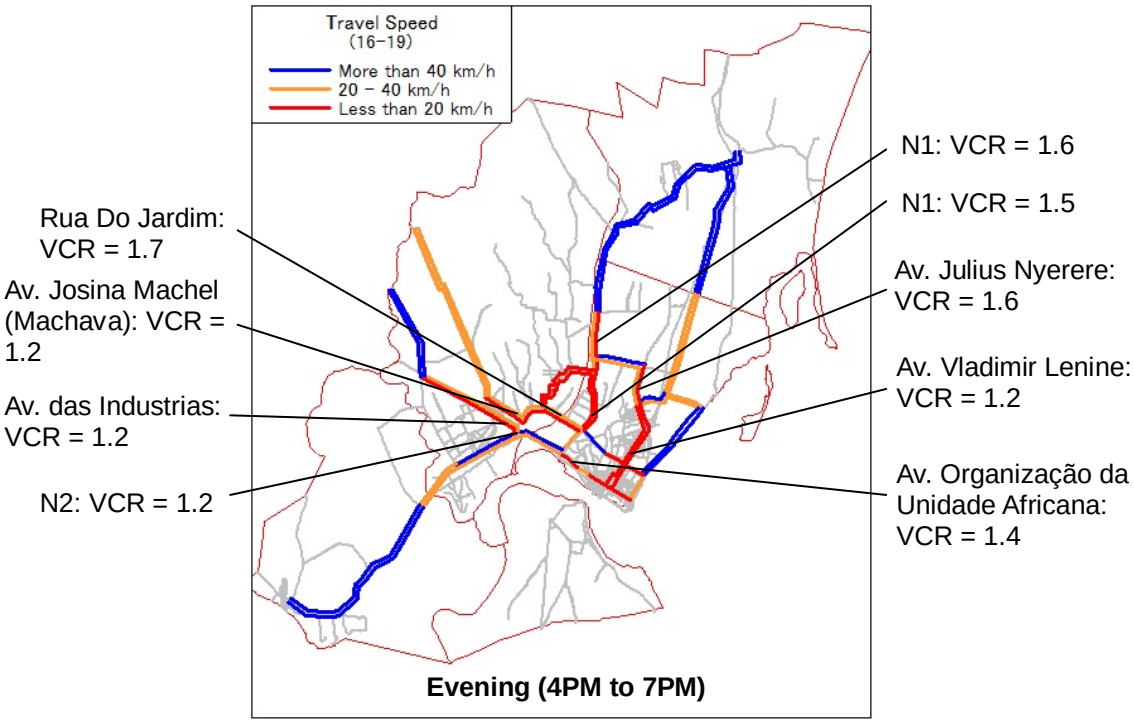
Figure 4.10: Estimated Travel Desire Lines in 2012 (All Modes)

Table 4.5: Zone Pairs with Largest Inter-Zonal Trips in 2012

No.	Zone Pair		Estimated Daily Trips	Remarks
1	DM KaMpfumu	DM KaMubukwana	143,256	North-South Axis
2	DM KaMpfumu	DM KaMaxakeni	139,185	North-South Axis, neighboring zones
3	DM KaMpfumu	DM KaMavota	134,914	North-South Axis
4	DM KaMpfumu	DM Nhlamankulu	99,597	North-South Axis, neighboring zones
5	DM KaMpfumu	Matola	85,540	East-West Axis
6	Matola	Machava	71,985	Suburb-to-suburb, East-West Axis
7	DM KaMpfumu	Machava	69,847	East-West Axis
8	DM KaMaxakeni	DM KaMavota	67,835	North-South Axis, neighboring zones
9	DM KaMpfumu	Influlene	66,753	North-South Axis, East-West Axis
10	DM Nhlamankulu	DM KaMubukwana	61,907	North-South Axis, neighboring zones

Source: JICA Project Team

However, it is estimated that the existing transport capacity of these corridors has already become insufficient. As shown in Figure 4.11, the travel speed at many key sections of these corridors is less than 20 km/h during peak hours. In addition, the volume-to-capacity ratio (VCR) at some of these sections is estimated to be quite high, indicating the urgent need for transport capacity expansion.



Source: JICA Project Team

Figure 4.11: Results of Travel Speed Surveys and Estimated Volume-to-Capacity Ratios (VCR) along Major Corridors in 2012

Without implementing major capacity expansion of these corridors, urban development along the corridors would likely be discouraged due to worsening of traffic congestion, which may undesirably tend to promote the uncontrolled urban sprawl (i.e., Scenario A). As described earlier, Scenario B can be considered half way under implementation, which in fact is indicated by the existence of these corridors linking several poly-centers in Greater Maputo. This undergoing trend is expected to continue as transport capacity expansion along the major corridors is implemented. The key to promote the Compact Corridor Development (Scenario C) is to develop further enhanced transport and commute corridors beyond those for Scenario B especially with the introduction of higher capacity mass transit systems. Considering the above-mentioned existing major corridors, the potential Compact Corridors in Greater Maputo are summarized in Table 4.6.

Table 4.6: Potential Compact Corridors in Greater Maputo

Corridor	Description
East-West Axis: Maputo CBD–Matola Sede–Belaluene	The linkage of Maputo CBD, Matola Sede, and Belaluene via the N2 and N4 or Av. das Industrias can be considered for potential Compact Corridor Development. The link between Matola Sede (also known as the "dormitory city" of Maputo) and Maputo CBD has historically been a major commuter corridor for the metropolitan area. In addition, this corridor has various economic potentials along its route. Many enterprises are concentrated in District KaMpfumu, District Nhlamankulu, and Matola Sede, which are transected by the corridor. Various manufacturing industries are located in Matola. Moreover, the Ports of Maputo and Matola are located along the corridor.
North-South Axis: Maputo CBD–Zimpeto	The linkage between Maputo CBD and Zimpeto via the N1 transects District KaMpfumu, District Nhlamankulu, and District KaMubukwana of Maputo, which are districts with high residential population. Furthermore, this corridor also has a significant amount of enterprise and industrial activity.

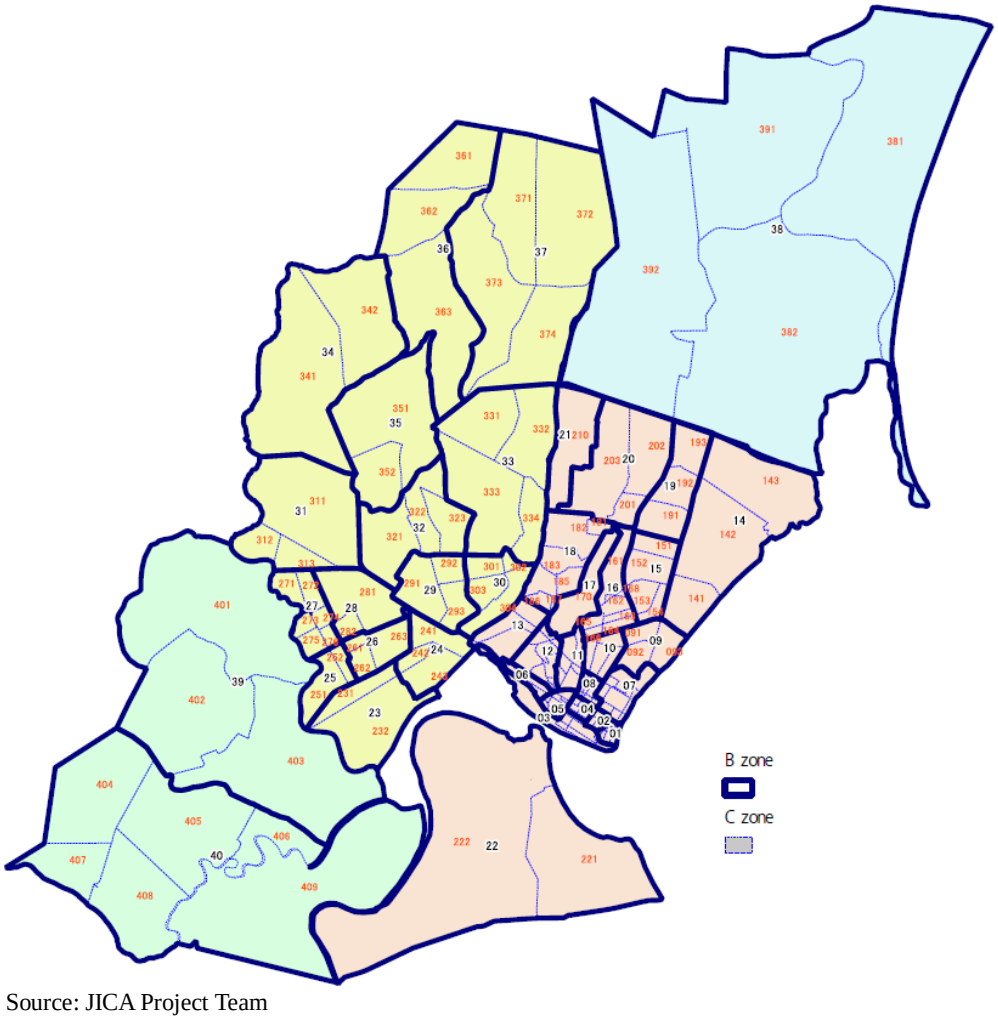
Corridor	Description
North-South Axis: Maputo CBD–Costa do Sol–Marracuene	The linkage between Maputo CBD–Costa do Sol–Marracuene via Julius Nyerere and Av. Coronel General Sebastiao Mabote (or Av. Cardeal Alexandre dos Santos) is anticipated to benefit the inhabitants and activities on the eastern side of the National Airport. The corridor runs through the emerging residential areas of Costa do Sol (Mapulene), Albazine, and Marracuene.

Source: JICA Project Team

4.7 Distribution of Future Population, Employment and Enrollment

4.7.1 Methodology

For the purpose of the HIS survey and transport modeling, districts of Greater Maputo have been zoned as shown in Figure 4.12. C-zones (shown in thin lines) are based on bairros (urban areas) which are the smallest level where census data is available. C-zones have been consolidated into B-zones (shown in thick blue lines) based on land-use patterns and major transport infrastructure. Socio-economic indicators of future population, employment and enrollment are distributed at the C-zone level for the purpose of the transport analysis.



Source: JICA Project Team

Figure 4.12: C Zones for Distribution of Population, Employment, and Enrollment

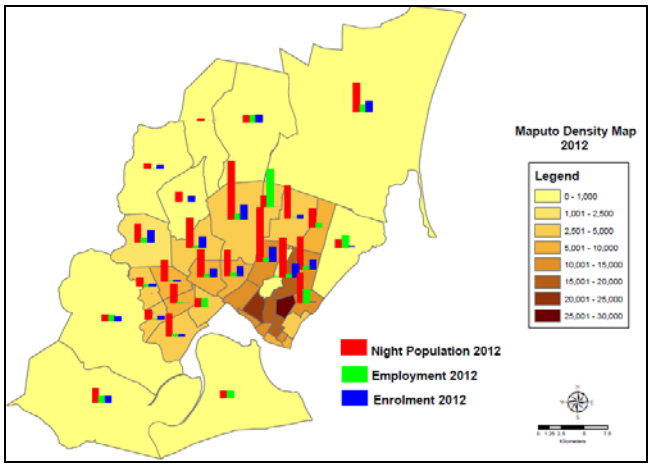
The distribution of population, employment, and enrollment by C-zone for the three scenarios were derived as follows:

- Scenario A (Trend Growth) is considered the baseline for the distribution of socio-economic indicators. For each scenario, the Greater Maputo grand total of population, employment, and enrollment were kept constant.
- For Scenario B (Polycentric Satellite Center Development Pattern), areas considered as growth centers were identified at the C-zone level. Socio-economic indicators were increased for growth center C-zones based on the predominant land use[5] and baseline socio-economic indicators in the zone. Similarly, socio-economic indicators were decreased for C-zones that were not considered growth center zones.
- For Scenario C (Compact Corridor Development), C-zones traversed by a railway and/or BRT route were identified. Socio-economic indicators were increased for C-zones traversed by a railway and/or BRT route based on the predominant land use and Scenario B socio-economic indicators in the zone. Similarly, socio-economic indicators were decreased for C-zones that were not traversed by a railway and/or BRT route.

The socio-economic distributions of the current and future alternative scenarios are summarized graphically in Section 4.7.2 to Section 4.7.6. The numerical indicators are summarized in Section 4.7.7.

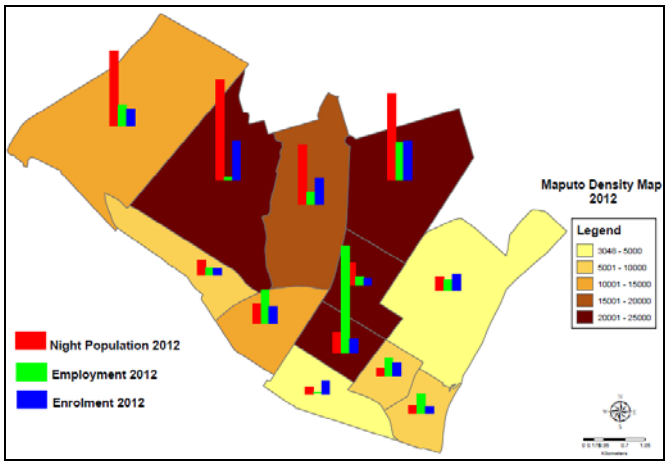
4.7.2 Current Socio-Economic Distribution

The current distribution of night time population, night time density, employment and enrollment is visually presented for Greater Maputo in Figure 4.13 and for Maputo City Central Business District (CBD) in Figure 4.14.



Source: JICA Project Team

Figure 4.13: Current Greater Maputo Socio-Economic Distribution



Source: JICA Project Team

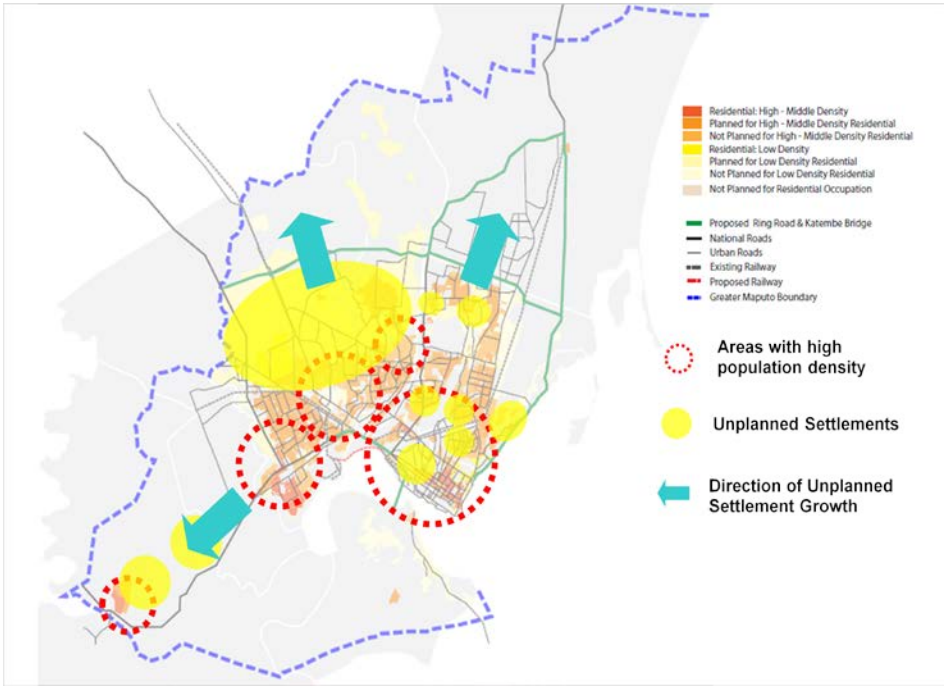
Figure 4.14: Current Maputo City CBD Socio-Economic Distribution

[5] For example, night time population was increased for C-zones with predominantly residential use, and employment was increased for C-zones with predominantly industrial use.

4.7.3 Scenario A: Trend Growth: Mono-centric Radial Development (Unplanned Growth)

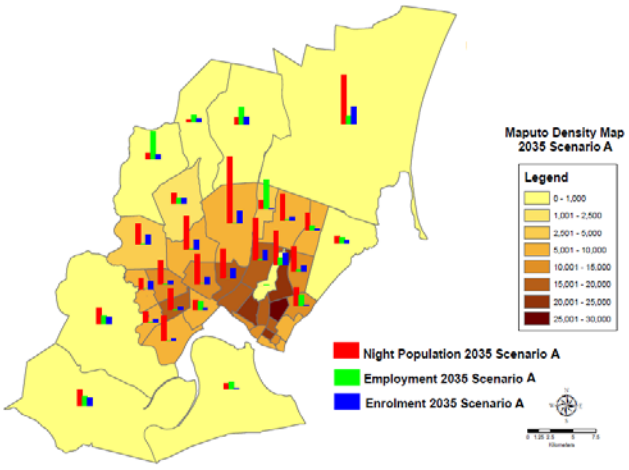
Figure 4.15 shows a conceptual diagram of trend growth. This can be considered unplanned growth that will lead to a mono-centric radial urban structure.

The socio-economic distribution for the trend growth is summarized in Figure 4.16 and Figure 4.17.



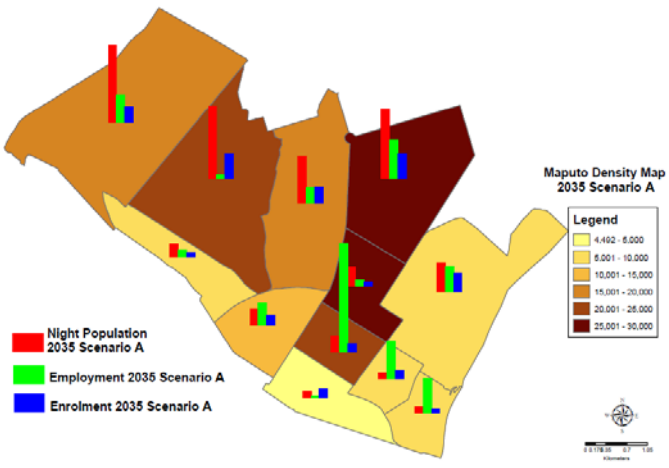
Source: JICA Project Team

Figure 4.15: Trend Growth:
Monocentric Radial Development Pattern



Source: JICA Project Team

Figure 4.16: 2035 Scenario A
Greater Maputo
Socio-Economic Distribution

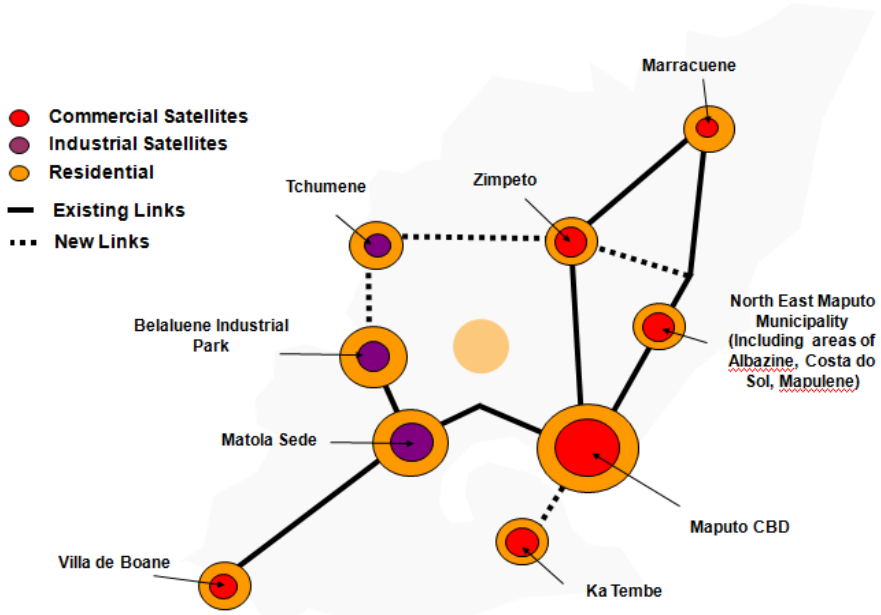


Source: JICA Project Team

Figure 4.17: 2035 Scenario A
Maputo City CBD
Socio-Economic Distribution

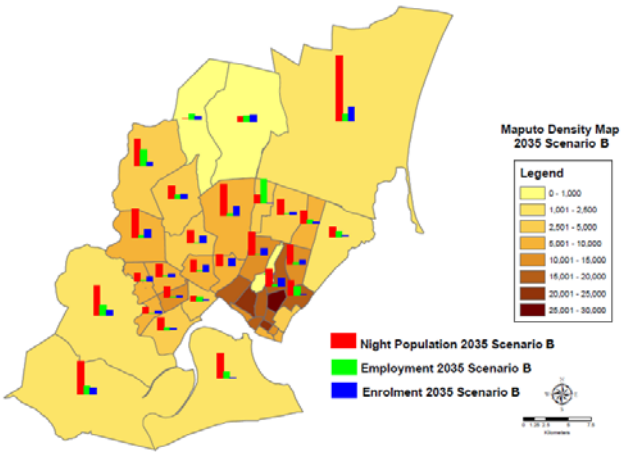
4.7.4 Scenario B: Polycentric Satellite Center Development Pattern

Figure 4.18 presents a conceptual diagram of polycentric satellite center development. The socio-economic distribution for polycentric satellite center development is summarized in Figure 4.19 and Figure 4.20.



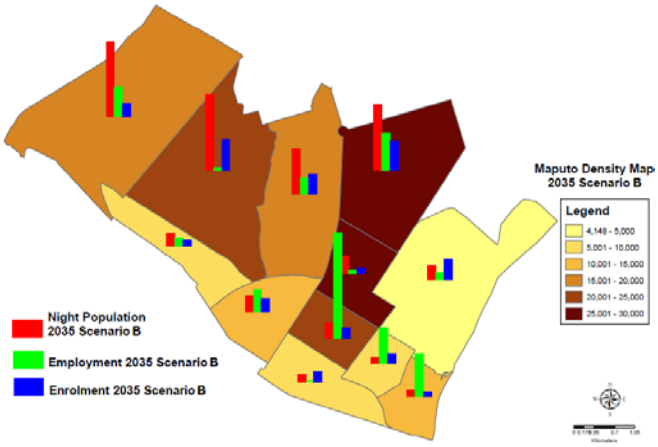
Source: JICA Project Team

Figure 4.18: Polycentric Satellite Center Development Pattern



Source: JICA Project Team

Figure 4.19: 2035 Scenario B Greater Maputo Socio-Economic Distribution Nighttime Population

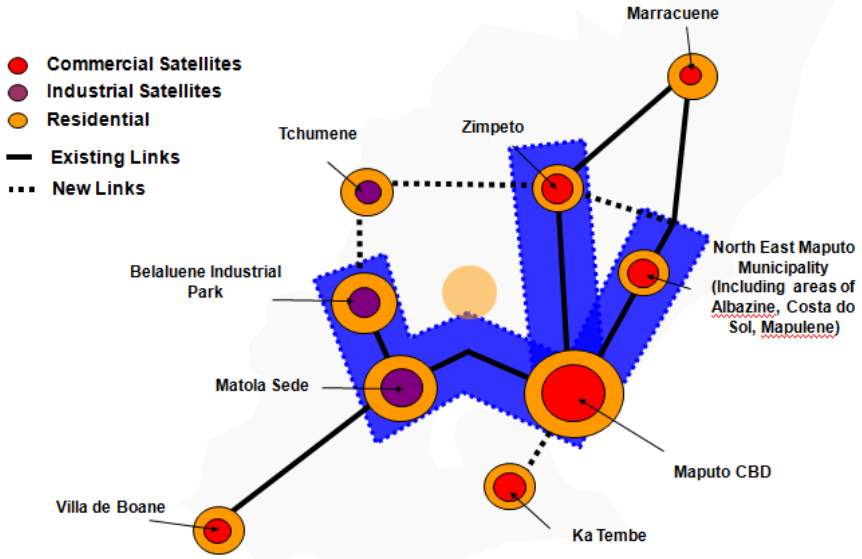


Source: JICA Project Team

Figure 4.20: 2035 Scenario B Maputo City CBD Socio-Economic Distribution

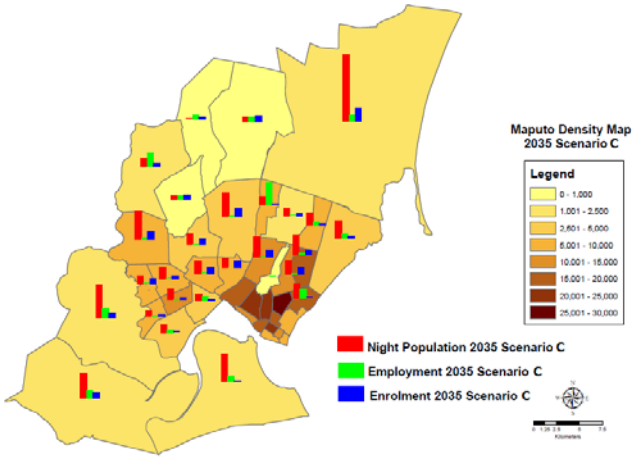
4.7.5 Scenario C: Compact Corridor Development

Figure 4.21 presents a conceptual diagram of compact corridor development, which maximizes the utilization of the areas between the poly-centers mentioned for polycentric satellite center development. The socio-economic distribution for the polycentric satellite center development is summarized in Figure 4.22 to Figure 4.23.



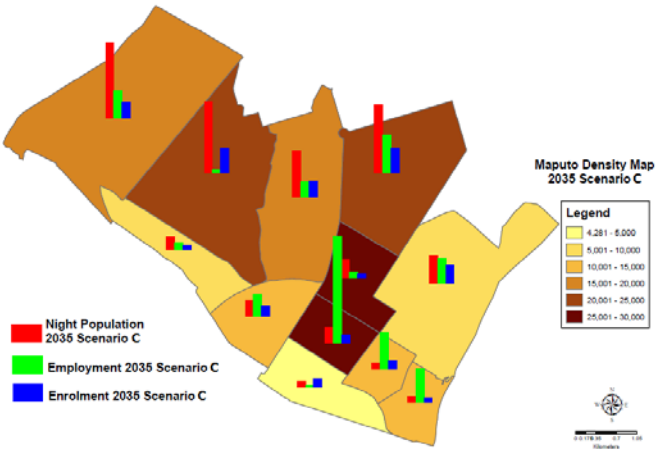
Source: JICA Project Team

Figure 4.21: Compact Corridor Development Pattern



Source: JICA Project Team

Figure 4.22: 2035 Scenario C Greater Maputo Socio-Economic Distribution

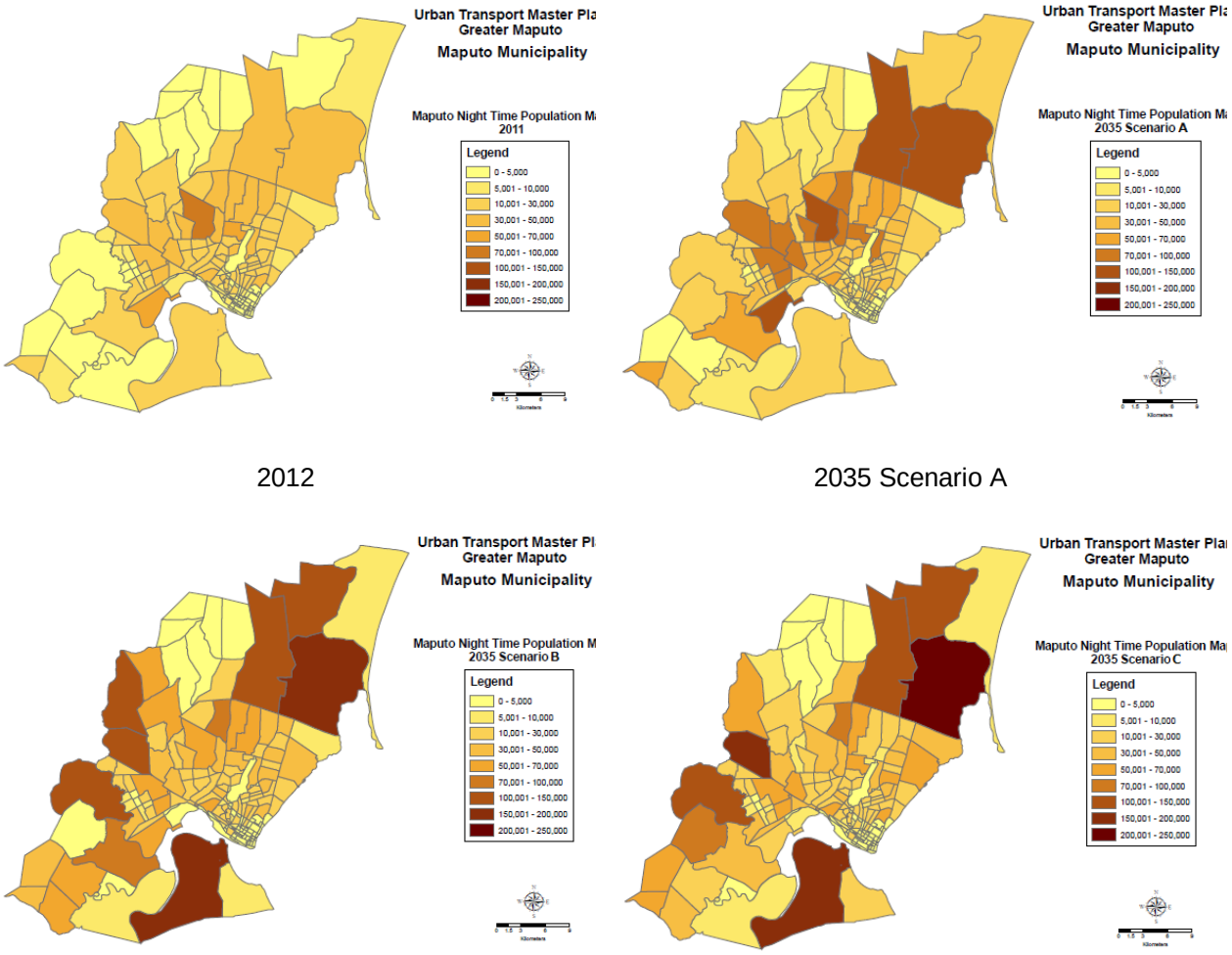


Source: JICA Project Team

Figure 4.23: Maputo City CBD Socio-Economic Distribution

4.7.6 Distribution Differences by Scenario

The differences in the distribution of night time population for the different scenarios are summarized in Figure 4.24. Further analysis is discussed in Technical Report D.



2012 2035 Scenario A

2035 Scenario B 2035 Scenario C

Source: JICA Project Team

Figure 4.24: Comparison of Night Time Population for Different Scenarios

Chapter 5 Development of Land Use/Transport Scenarios and Urban Transport Development Strategies

5.1 Introduction

This chapter sets out alternative land use scenarios for Greater Maputo and presents the urban transport development vision and strategy examined and agreed among stakeholders in the course of the project. Subsequently, transport network options are developed for 2035 based on the land use scenarios, the transport vision and strategy, and major transport development initiatives that are urgently required.

5.2 Alternative Land Use Scenarios

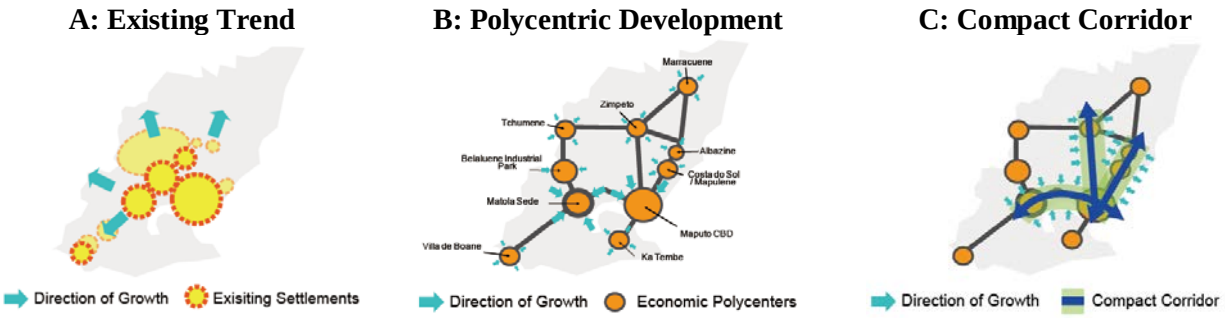
Three alternative urban development scenarios set out in Chapter 4 were considered to identify the preferred land use and transport development scenario(s). The three scenarios considered include the following (see Figure 5.1).

- Scenario A: Existing Trend
- Scenario B: Polycentric Development
- Scenario C: Compact Corridor

In terms of land use, Scenario A could be termed "business as usual", as it is based on the extrapolation of existing trends, such as urban sprawl and the growth of informal settlements in the absence of land use plans and corresponding enforcement of development controls.

Scenarios B and C represent changes to land use development, coupled with more rigorous development and enforcement of land use plans and zoning. Shown in Figure 5.1, Scenario B is predicated upon the development of a polycentric city, i.e., the development of secondary central business districts in addition to the Maputo City Center ("Baixa".) This should enable more work-based trips to occur to/from areas other than central Maputo, with the intention of relieving traffic congestion levels and pressure on property prices in Maputo city center. As described in Chapter 4, Scenario B would entail major public investment in the transport capacity improvement along corridors linking various poly-centers.

Scenario C develops beyond polycenters into development intensification along key transit corridors that are further enhanced beyond those for Scenario B, thereby achieving higher development densities along key bus spines and potential BRT routes, plus development along potential commuter rail networks. The aim of Scenario C is to better align property development with transport service provision, particularly public transport networks.



Source: JICA Project Team

Figure 5.1: Examined Land Use Patterns

These alternative scenarios are considered in developing the urban transport development strategies and transport network options in the sections that follow.

5.3 Urban Transport Development Vision and Strategy

5.3.1 Vision and Strategy Agreed by Steering Committee

Based on the analyses of existing transport conditions and issues in Greater Maputo, the urban development vision and strategy described in Chapter 4, and the alternative land use scenarios set out in the preceding section, urban transport development vision and strategy were examined jointly by the JICA Project Team and stakeholders in the course of this project including at workshops and Steering Committee meetings.

The transport development vision agreed by the Steering Committee for the project is summarized in Figure 5.2.

Urban Transport Development Vision:

Greater Maputo as a

"Socially and Environmentally Sustainable Urban Transport Systems facilitating the International Gateway Capital"

The Urban Transport Development Vision in Detail:

Socially Sustainable Urban Transport	Environmentally Sustainable Urban Transport	Urban Transport facilitating the International Gateway
• Provide mobility and accessibility for all citizens (including low-income, foreigners, disabled, elders, and children) • Safe and secure transport systems that contribute to poverty reduction by improvement of economic efficiency • Encourage use of universal design • Minimize social impact (e.g., minimum land acquisition for development, etc.)	• Urban transport systems that minimize adverse impact on environment (e.g., minimum CO_2 emission, conserve natural environment, preserve and improve city landscape) • Minimize the use of fossil fuels • Use of clean and quiet transport systems	• Transport systems to support sustainable urban development and economic growth • Transport systems operating at international standards • Transport systems that support mobility for people and goods • Transport systems that consider positive impacts not only on Greater Maputo but also surrounding areas

Source: JICA Project Team

Figure 5.2: Urban Transport Development Vision for Greater Maputo

To achieve the transport development vision for Greater Maputo, the following development strategies were agreed upon:

- **Increase mobility/accessibility by improving public transport systems** (related to Public Transport)
- **Road network development with consideration to functions/hierarchy** (related to Road Network)
- **Better use of road space and improve vehicle/pedestrian environment** (related to Traffic Management)

Specific strategies for each were set out as described below.

(1) Increase Mobility/Accessibility by Improving Public Transport Systems (Public Transport)

Strategy:

1. Introduce mass transit systems (e.g., commuter rail, LRT, BRT) with a higher level of service by harmonization with surrounding environment
2. Make public transport more convenient, faster, more comfortable, cleaner, and safer for all users (including children, elderly, disabled)
3. Improve public transport infrastructure including terminals, intermodal facilities, bus priority lanes and exclusive bus right of way where appropriate with effective utilization of resources, including land
4. Ensure use of appropriately specified vehicles for each type of service
5. Develop and enforce appropriate regulations, and formalize public transport industry structure in order to become an example of good practice for other cities in Mozambique and other countries
6. Implement financially sustainable fare structures
7. Development of polycentric commercial and business districts to decentralize economic activity

Outputs:

1. Modal shift from private car to public transport
2. Fewer private cars on the road leading to reduction in traffic congestion
3. Resulting socio-environmental benefits (reduced pollution, transport costs, and travel time, as well as increased accessibility)
4. Sustainable public transport system

(2) Road Network Development with Consideration to Functions/Hierarchy (Road Network)

Strategy:

1. Restrict use of private vehicles while improving road network
2. Develop necessary links and improve conditions to strategic areas to enhance accessibility
3. Strengthen road maintenance capacity
4. Improve drainage system
5. Sustain cultural and environmental amenities and green area
6. Develop road user information systems (ITS)
7. Minimize any environmental and social impacts for road network improvement

Outputs:

1. Decreased traffic congestion
2. Increased accessibility
3. Decreased transport costs, both actual costs (gasoline, tariffs) and opportunity costs (travel time)
4. Decreased negative environmental impacts
5. Establishment of road network for all weather conditions
6. Sustainable city landscape
7. Facilitation of interregional and international exchanges
8. Guiding of industrial and residential development

(3) Better Use of Road Space and Improve Vehicle/Pedestrian Environment (Traffic Management)

Strategy:

1. Implement various traffic management measures including intersection improvement, signals, one-way systems, high occupancy vehicle (HOV) lanes, tidal flow, bus priority lanes, and area licensing

2. Control use of private vehicles by introducing various TDM measures (e.g., congestion charging, parking management)
3. Develop and enforce regulations (e.g., for parking, road safety, drinking driving, speeding)
4. Improve traffic calming and safety measures to improve road and pedestrian environment including pedestrian signals, sidewalk, road sign, road marking, safety measures for elderly and disabled, and pedestrian malls

Outputs:

1. Reduced traffic congestion
2. Improved pedestrian environment (Convenient, clean, healthy, and safe)
3. Reduction in accidents
4. Optimized road conditions and fewer conflicts by decreased road congestion from parking
5. Better connectivity and efficiency from travel control improvements (reduced delays)

5.3.2 Addressing Major Transport Issues/Challenges

While the vision and the strategies set out above are relatively broad, they can adequately address particularly important issues/challenges summarized in subsection 2.3.1 of Chapter 2, as shown in Figure 5.3.

Major Development Initiatives Urgently Needed		**Relevant Strategies**
Maputo-Matola (**East-West Axis**) Transport Development	• Introduce mass transit systems between Maputo and Matola • Improve transport systems for Matola suburban and industrial development and for sustainable metropolitan growth (Improve suburb-to-suburb transport between central/northern Maputo Municipality and Matola/Machava in the medium term)	PT: 1 to 7 Road: 1 to 7
North-South Axis Transport Development	• Introduce mass transit systems between Maputo CBD and central/northern Maputo Municipality • Improve transport systems for better accessibility between Maputo and Marracuene and for sustainable metropolitan growth • Align transport development with environmental improvement along the coastline	PT: 1 to 7 Road: 1 to 7
Increasing Provision of Quality Public Transport Services	• Introduce quality mass transit systems along the East-West Axis and the North-South Axis • Develop capacity of the public transport sector in the short term (Restructure the sector in the medium term) • Initiate establishment of effective Greater Maputo urban transport institution	PT: 1 to 7 Road: 1, 2 among others
Addressing Traffic Bottlenecks	• Remove major bottlenecks/hotspots in the short term (Implement TDM measures in the medium to long term) • Upgrade traffic signal system in stages • Implement related measures to move toward greater control or enforcement of related regulations	TM: 1 to 4

Note: Relevant Strategies in the figure are those related to these initiatives among the strategies set out in the preceding subsection. PT stands for public transport, Road for road network, and TM for traffic management.
Source: JICA Project Team, subsection 2.3.1 of Chapter 2

Figure 5.3: Addressing Major Transport Issues/Challenges

5.4 Alternative Transport Scenarios

5.4.1 Outline

Alternative scenarios for transport network development in Greater Maputo were developed based on the following considerations:

- Develop scenarios that correspond to the land use scenarios presented in Section 5.2
- Improve public transport systems significantly based on the urban transport development strategies set out in the preceding section
- Include scenarios with mass transit systems development along heavily congested routes/sections (e.g., commuter rail, LRT, BRT)
- Expand transport capacity significantly along the Maputo–Matola Axis (East-West Axis) and the North-South Axis as indicated in subsection 2.3.1 of Chapter 2
- Improve suburb-to-suburb transport, e.g., between central/northern Maputo Municipality and Matola/Machava, the demand for which is relatively high and is expected to grow rapidly (see subsection 2.3.1)

Three transport network options proposed are as follows:

- **Scenario A:** "Do Minimum" in terms of transport network development (though ongoing and already committed projects are included). Scenario A corresponds to Land Use Pattern A [**Existing Trend**] (see Section 5.2)
- **Scenario B:** Development of mass transit systems, i.e., Bus Rapid Transit (BRT) network with reform of buses and chapas. Scenario B corresponds to Land Use Pattern B [**Polycentric Development**] that would entail major public investment in the transport capacity improvement along corridors linking various poly-centers as described in Section 5.2 and Chapter 4.
- **Scenario C:** Development of mass transit systems including commuter rail in addition to BRT, with bus and chapas networks restructured accordingly. Scenario C corresponds to Land Use Pattern C [**Compact Corridor**] that is considered to require even greater transport investment than Scenario B along key transit corridors as described in Section 5.2 and Chapter 4.

5.4.2 Alternative Transport Network

(1) Scenario A

The transport strategy assumed for Scenario A is the closest of the three to existing practice, but also includes bus priority corridors in order to increase the provision of public transport services. Figure 5.4 shows a schematic transport network for Scenario A in 2035. The green lines in this figure represent Bus Priority Lanes that will be used to ensure that delays to bus journeys are reduced on key congested routes. Dedicating road space to buses will affect car journey times, as road space for cars will be reduced. Nevertheless, by removing buses from the car traffic stream, a more stable flow might be achievable.

The proposed bus priority routes include major roads along the Maputo–Matola (East-West) and North-South transport axes mentioned above.

Source: JICA Project Team

Figure 5.4: Scenario A Schematic Transport Network for 2035

(2) Scenario B

Scenario B additionally entails the development of Bus Rapid Transit (BRT), as shown in Figure 5.5. In this scenario, BRT is used instead of priority measures for street-running buses across much of the trunk bus network. This is to achieve substantial increase in transport capacity across the network relative to Scenario A and feed the polycenters predicated under the respective land use scenario. Moreover, bus and chapa networks are restructured to improve service. Operational efficiency improvements within Transporte de Moçambique (the Maputo public bus company) are also assumed.

Source: JICA Project Team

Figure 5.5: Scenario B Schematic Transport Network for 2035

(3) Scenario C

Under Scenario C shown in Figure 5.6, there is the additional development of a commuter railway, (partly) requiring the upgrading of existing rail facilities. These rail and BRT corridors will enable transit-oriented development along the corridors and around railway stations.

Source: JICA Project Team

Figure 5.6: Scenario C Schematic Transport Network for 2035

5.4.3 Comparison Among Scenarios

Table 5.1 compares the three transport network options in various aspects including corresponding land use pattern, achievable transport capacity, population and employment distribution patterns, overall mobility and accessibility, sustainability of urban growth, and the extent of anticipated air pollution. Chapter 6 presents the result of quantitative assessment of these options undertaken based on transport network simulation, and identifies the preferred scenario.

Table 5.1: Comparison among Transport Network Options

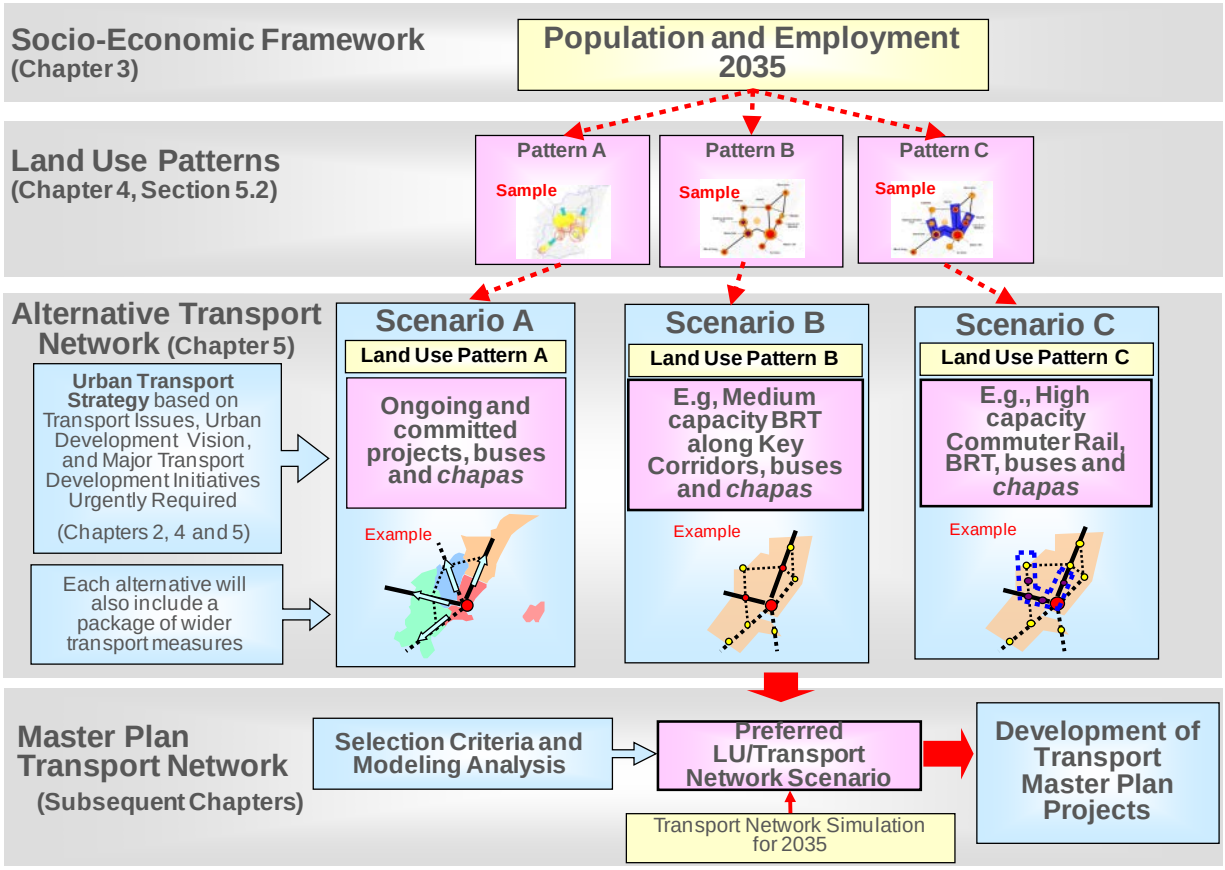
Item	Scenario A	Scenario B	Scenario C
Main characteristics	**Do Minimum:** Only ongoing and committed projects proceed with bus priority lanes introduced. Automobile-oriented. Bus and chapas operate as at present	**Bus Rapid Transit (BRT):** Automobile and mass transit with BRT network developed. Public transport includes BRT, buses, and chapas	**BRT and Commuter Rail:** Mass transit (commuter rail, BRT, buses for feeder, or a combination of these), a relatively lower role of automobiles in urban areas
Corresponding land use pattern	**A: Existing Trend** Existing trend, uncontrolled urban sprawl, lower density development	**B: Polycentric Development** Decentralized multi-core development, lower level of concentration in the CBD	**C: Compact Corridor** High-density development along mass transit routes, decentralized industrial and commercial activities
Transport capacity along major axes	Lower without dedicated lanes/routes for public transport	Medium with BRT	Higher with commuter rail transport in addition to BRT
1) Suburban population 2) Relevant transport characteristics	1) Lowest among the three 2) Public transport is least developed, restricting people from moving further out.	1) Higher than A and nearly equal to C 2) BRT network allows people to live further from Maputo CBD than A.	1) Higher than A and nearly equal to B but more concentrated along rail/BRT routes than B 2) Mass transit especially rail induces more densely populated transit corridors than B.
1) Population of areas around Maputo CBD 2) Relevant transport characteristics	1) Highest among the three 2) With public transport least developed, population growth just outside Maputo CBD is most intense among the three.	1) Lower than A and nearly equal to C 2) BRT network allows a large part of population to live farther, leaving population growth around CBD less intense than A.	1) Lower than A and nearly equal to C 2) BRT and rail networks allow a large part of population to live farther, leaving population growth around CBD less intense than A.
1) Maputo CBD population 2) Relevant transport characteristics	1) Nearly equal to B 2) With public transport least developed, some population growth can be seen due to do convenience and accessibility to commercial activity, and lack of other alternatives.	1) Nearly equal to A 2) With BRT network, population growth will occur at poly-centers including the CBD due to increased convenience and accessibility	1) Somewhat higher than B 2) With BRT and rail networks, the convenience and accessibility of the CBD is the highest among the scenarios, and thus the CBD becomes a highly desired real estate
1) Employment distribution 2) Relevant transport characteristics	1) Employment opportunities follow current trend, primarily focused in Maputo and Matola 2) Locations of employment remain limited and increased commute time on road increases cost for employers/employees	1) Employment opportunities in Boane and Marracuene improved than A 2) Cost of commute slightly improved due to potentially shorter commute and less traffic congestion during peak hours	1) Employment opportunities in Boane and Marracuene more improved than A and B 2) Cost of commute significantly improved due to potentially shorter commute and less traffic congestion during peak hours

Item	Scenario A	Scenario B	Scenario C
Overall mobility	Lower due to lower average transport speed	Medium with average transport speed higher than A with BRT network development but lower than C	Higher due to higher average transport speed with rail development and higher capacity of overall mass transit system
Overall accessibility	Lower with the least developed urban transport among the three	Medium with longer average travel distance per trip than A	Higher with the longest average travel distance per trip among the three
Sustainability of urban growth	Lower due to uncontrolled urban sprawl	Medium with decentralized multi-core development	Higher than B with longer commuting distance enabled by faster mass transit systems
Extent of anticipated air pollution	Higher due to lower public transport modal share and lower average vehicle speed	Medium, considerably lower than A due to higher average vehicle speed	Lower due to higher public transport modal share than B

Source: JICA Project Team

5.5 Summary

Figure 5.7 summarizes the flow of developing the alternative land use/transport patterns and selecting the master plan transport network.



Source: JICA Project Team

Figure 5.7: Flow for Development of Master Plan Transport Network

Chapter 6 Future Traffic Demand and Evaluation of Transport Development Scenarios

6.1 Introduction

This chapter presents the procedures and results of traffic demand forecasts including the traffic assignment for alternative transport development scenarios, and the evaluation of these scenarios to select the Master Plan transport network as the preferred network to be developed for year 2035.

Technical Report N "Demand Forecasting: Methodology and Analysis" contains further details of the modeling methodology and results.

6.2 Demand Forecasting Procedure

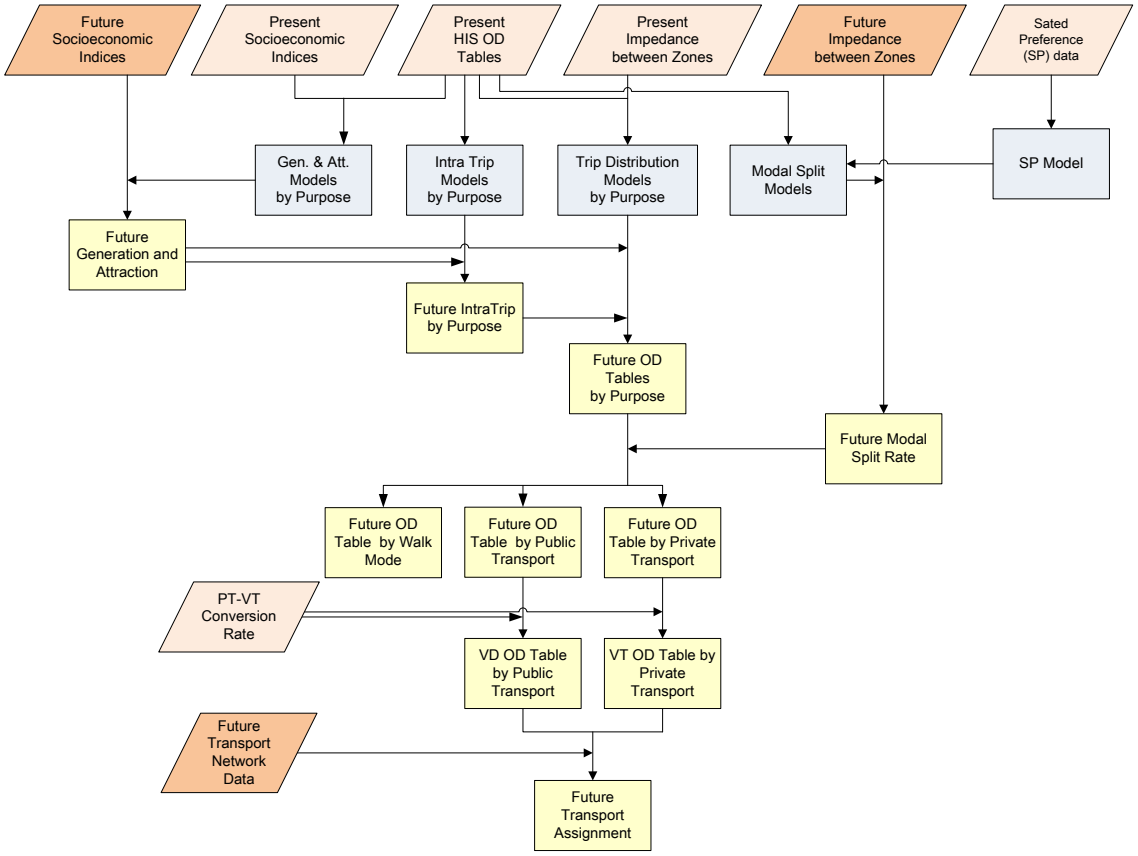
Figure 6.1 shows the flowchart which was employed in developing and calibrating the demand forecasting model.

The key components in the demand forecasting model can be summarized as follows:

- Commonly-used 4 step traffic demand forecasting method was adopted
- SP model[1] was used to split the future mass transit at the future modal split model
- Three types of future land use patterns were reflected in the future socioeconomic indices, then reflected to the trip generation and attraction forecasting at the first step
- Future demand were assigned to the transport networks which includes road, bus, BRT and rail networks

Transport models were made by using the JICA STRADA software suite.

[1] Stated Preference (SP) survey is the method to quantitatively understand the mind and conditions of persons who want to use new transportation, and SP model is used to estimate the modal choice probability by individuals in the case that new transportation is installed.



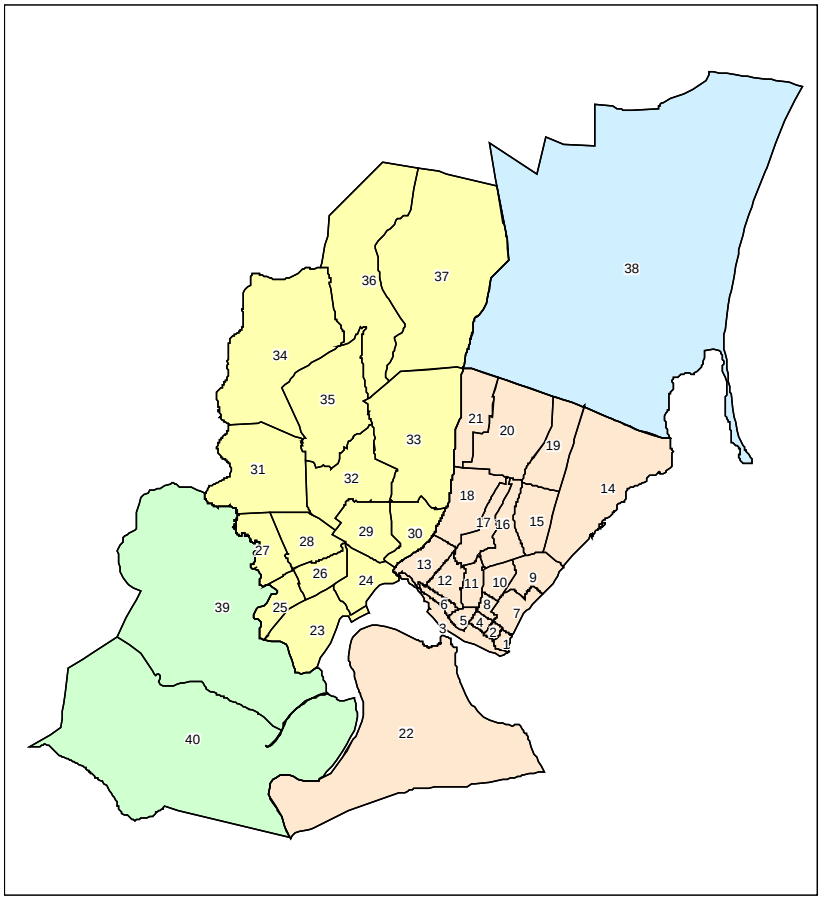
Source: JICA Project Team

Figure 6.1: Flowchart of Traffic Demand Forecasting

(1) Zoning

There were two zoning systems for the demand forecasting analysis:

- **B-zones: Zoning level** adequate to examine the arterial traffic network (see Figure 6.2). The size of the B-Zone was set using the "Bairro", the smallest unit used for the population census data. A part of the suburbs were zoned in a way that consolidated a few bairros. The number of zones within the study area was 40.
- **C-Zones:** Zoning level that divided the urban center into smaller sections to assess the detailed forecast and planning. For the C-Zone, bairros were broken down into smaller sections to accommodate the road network in the city center, whereas bairros were used as the smallest unit in the suburb. The number of zones within the study area was 170.



Source: JICA Project Team

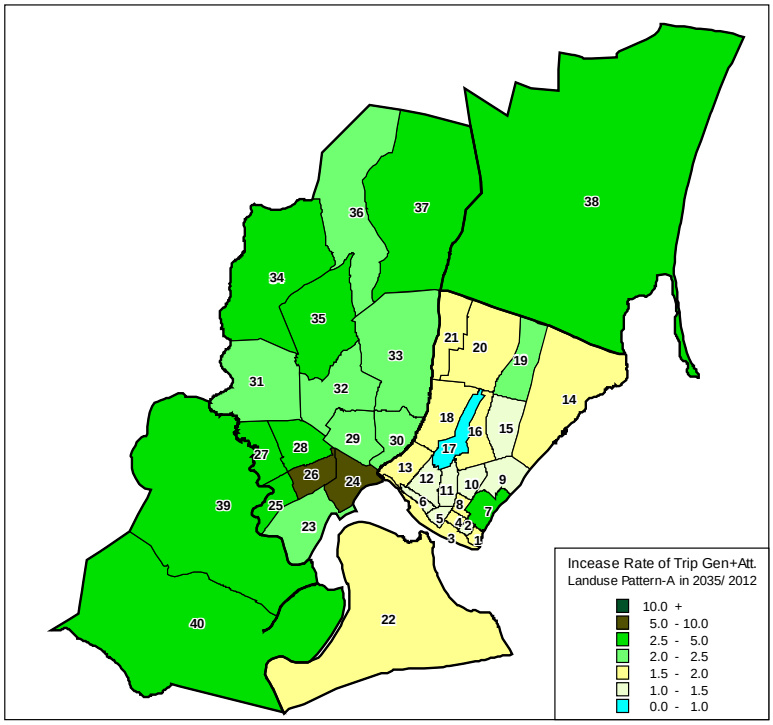
Figure 6.2: Zoning (B-Zone)

(2) Four Step Traffic Model

Step 1: Trip Generation and Attraction

The first step of the four-stage model is to predict the total number of trips generated and attracted to each zone of the study area. The total trip produced in the study area was forecasted, and then the trip production and trip attraction for each zone were calculated. Furthermore, adjustments were made to equalize the total trips generated and attracted by zone with the total trip produced in the study area.

Using the trip generation/attraction models, the trip generation/attraction for 2035 for three land use patterns was calculated. Then, adjustments were made so that the total trip generation/ attraction would equal the total trip production. Figure 6.3 shows the increase rate of trip generation and attraction in the case of the existing trend in land use patterns by 2035. This shows that the population of Maputo in its city centre becomes 1.0 to 1.5 times the size, and most of the other areas become around 1.5 to 2.0 times. Meanwhile, in Matola, Zone 24 and Zone 26 along N4 increase by about 6 to 7 times than the current amount, but other areas are 2.0 to 5.0 times. In Marracuene and Boane, the rate of increase will be 2.5 to 5.0.



Source: JICA Project Team

Figure 6.3: Classification of B-Zone by Increase Rate of Trip Generation and Attraction between 2012 and 2035 (Land Use Pattern A [Existing Trend])

Step 2: Trip Distribution

The second step of the four-stage model calculates the number of trips made between zones within a study area. In this survey, the trips between zones were calculated first, followed by the trips within zones. The trip distribution model is described in detail in Technical Report N and a selection of future distribution below in Section 6.3.

Step 3: Modal Split

Modal split (or modal choice), the third step in the four-stage transport forecasting model, is the process of determining which form of transport is used by travelers. Although the HIS classified the type of travel mode into 17 categories, forecasting traffic demand in line with this categorization was unrealistic. Therefore, the mode of travel was integrated into three types required to consider the master plan. These are walk/bicycles, private transport (motorcycle/car/ taxi/truck), and public transport (chapas/bus/ferry/etc.).

When examining the modal share in 2035 and comparing it to that of 2012, it is shown that the growth rates when using existing trends of land use include a 4.3 increase of car trips, 35.0 increase for motorcycle trips; and a 1.7 growth rate increase by public transport.

Step 4: Traffic Assignment

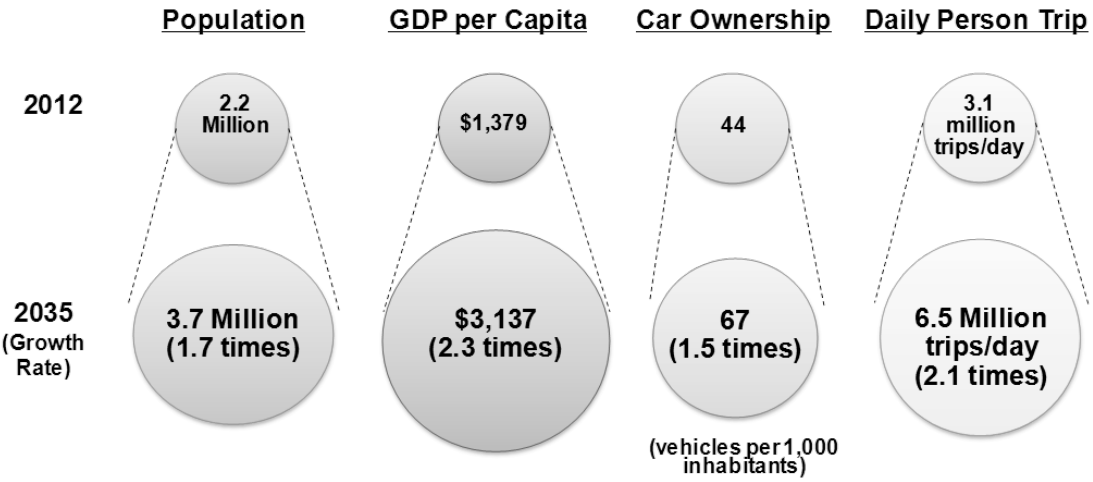
Traffic assignment is the final stage of the four-stage travel demand model. In the three previous stages, the number of trips by each mode between each pair of zones has been found. In the assignment stage, the trips are allocated to links through the network and the future traffic volume is calculated for each link. The basic premise of assignment is that each traveler chooses the route which offers them the minimum perceived cost.

For this study, the public transport OD traffic was first assigned onto the transport network, then private transport OD traffic assigned. To provide more detail, public transport OD was assigned prioritizing mass public transport, then for the OD traffic exceeding the capacity would be considered ordinary bus users and assigned onto the road. Then the traffic volume for each link for the buses assigned to the road were used as the initial traffic volume in assigning private vehicle OD chart, then assignment calculation was conducted.

Example assignment outputs are shown in Section 6.4.

6.3 Outline of Future Traffic Demand Forecasts

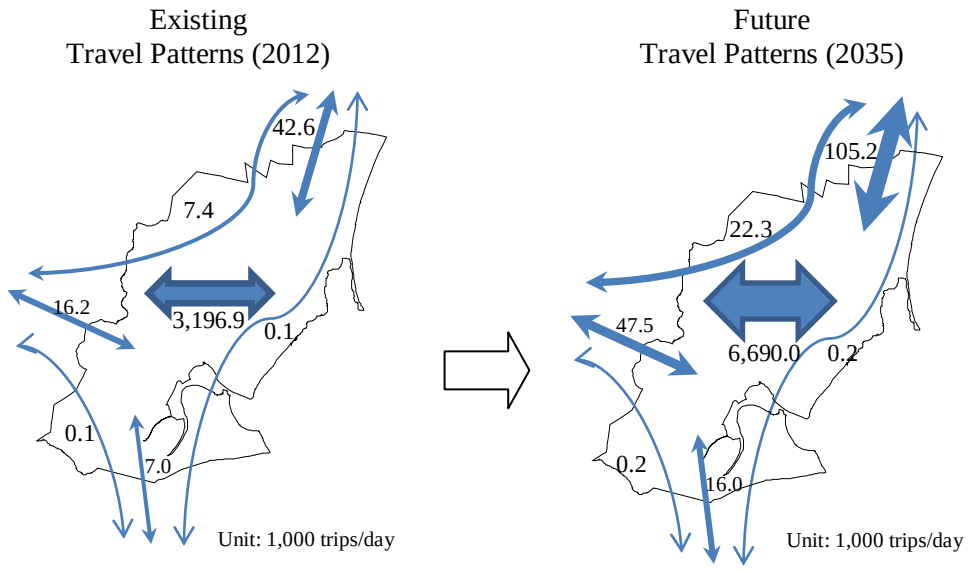
Figure 6.4 shows the growth in population and GDP per capita expected (and assumed in the model) from 2012 to 2035, along with the resultant growth in car ownership and daily person trip totals.



Source: JICA Project Team

Figure 6.4: Growth in Population, Economy and Traffic Demand, 2012–2035

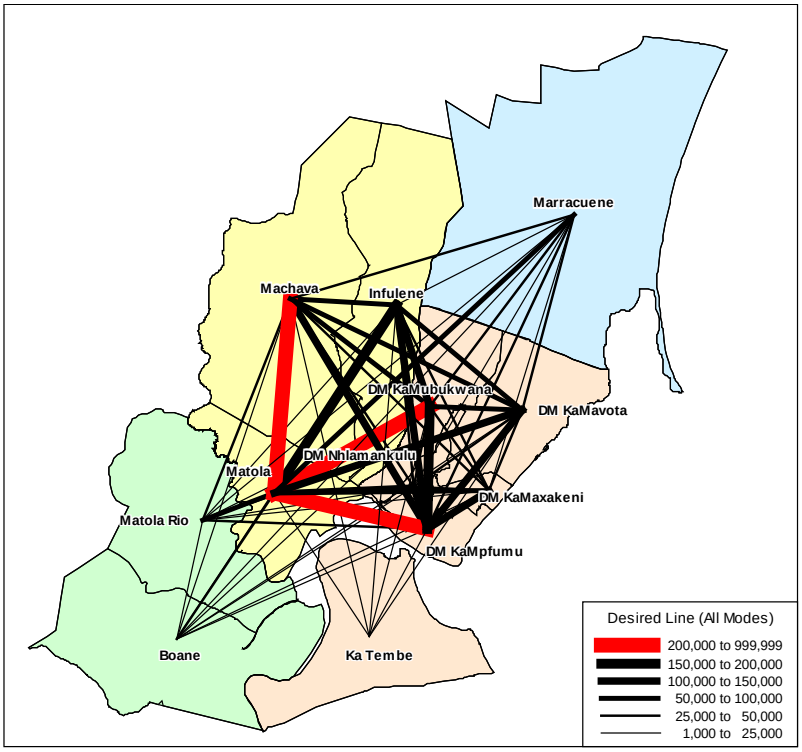
Figure 6.5 shows schematically the resultant impacts on travel patterns in 2035 and how these compare to 2012 trends. Trip levels inside Study Area are expected to grow from 3,100,000 in 2012 to 6,500,000 in 2035. While the volume in absolute terms is relatively small, there will be a sizeable percentage growth expected in trips into and out of the Study Area (e.g. growth from 16,200 trips per day between Greater Maputo and the West in 2012 to 47,500 trips per day in 2035).



Source: JICA Project Team

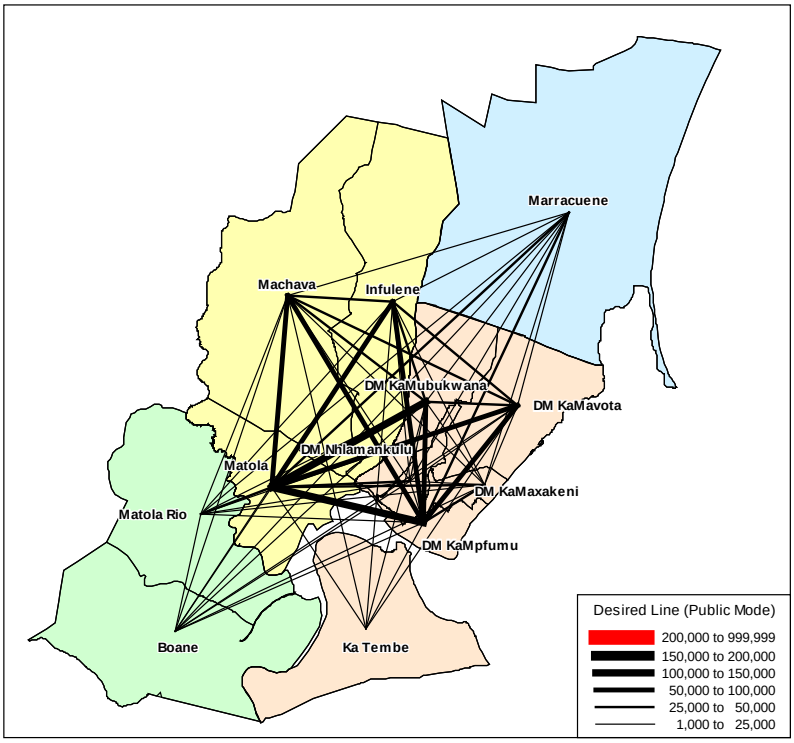
Figure 6.5: Growth of Traffic Demand in Greater Maputo, 2012–2035

Figure 6.6 shows desire lines (outlines of areas between which traffic demand occurs) for 2035 in further detail. Similarly, Figure 6.7 shows desire lines specifically for public transport trips.



Source: JICA Project Team

Figure 6.6: Desire Lines in 2035
(All Modes, Land Use Pattern A [Existing Trend])



Source: JICA Project Team

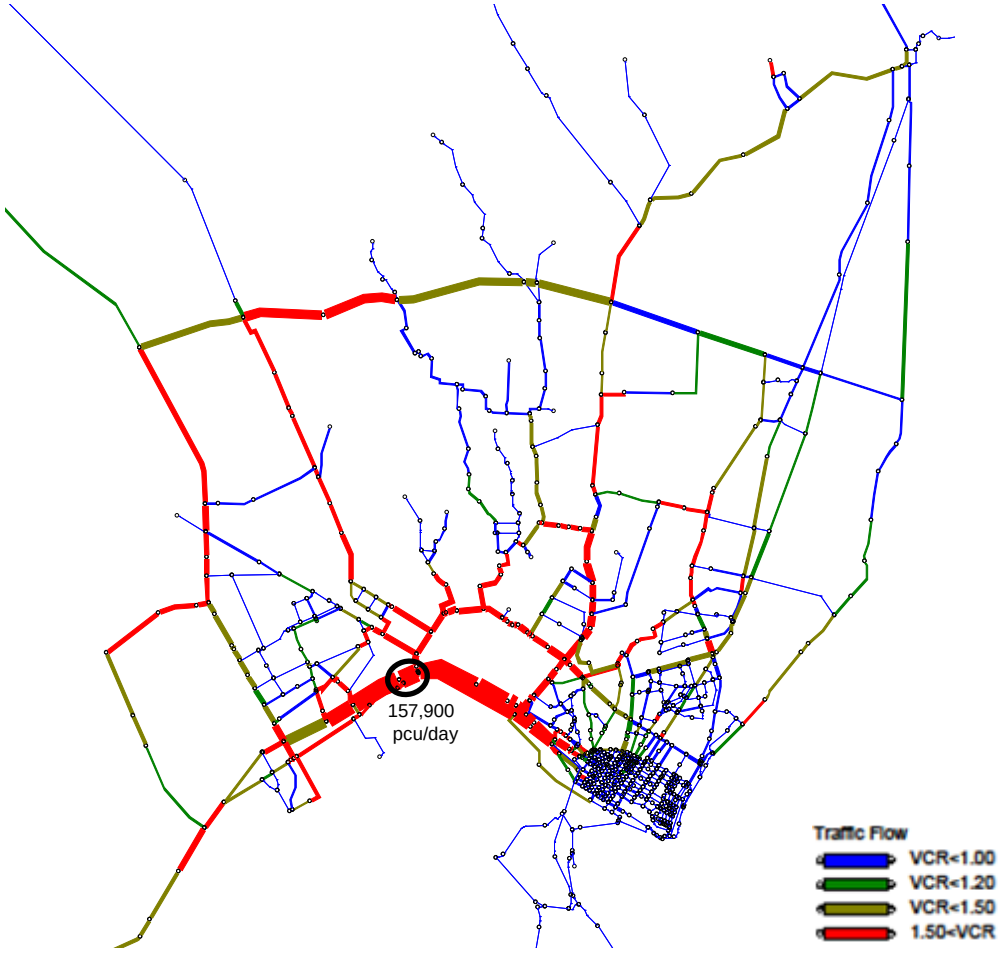
Figure 6.7: Desire Lines in 2035
(Public Transport Mode, Land Use Pattern A [Existing Trend])

6.4 Trip Assignment for Alternative Scenarios

Figures 6.8–6.10 show the results of 2035 traffic assignment for the three transport network options including Scenario A (the "Do Minimum Case"), Scenario B, and Scenario C set out in Chapter 5. In these figures, volume-to-capacity ratios (VCR) are indicated in different colors according to their levels.

In Scenario A (the "Do Minimum Case") (Figure 6.8) in which only the existing roads and roads that are currently being constructed are included, there is heavy congestion expected on the main arterial roads in 2035. The ring road will even have sections with more than 1.5 in the level of congestion. For the N4 road between Maputo and Matola, 160,000 PCU/day is expected. In addition to other links with more than 1.5 level of congestion particularly in Matola and Maputo, there are a number of other sections right across the network with congestion levels up to 1.5.

The implications of such congestion include severe delays and unreliability for private and public transport vehicles, increased noise and air pollution, and worsening environment for pedestrians, etc. The result suggests that **a mass transit network needs to be developed in Greater Maputo, which is capable of meeting future travel demand without causing severe congestion in many parts of the study area.**



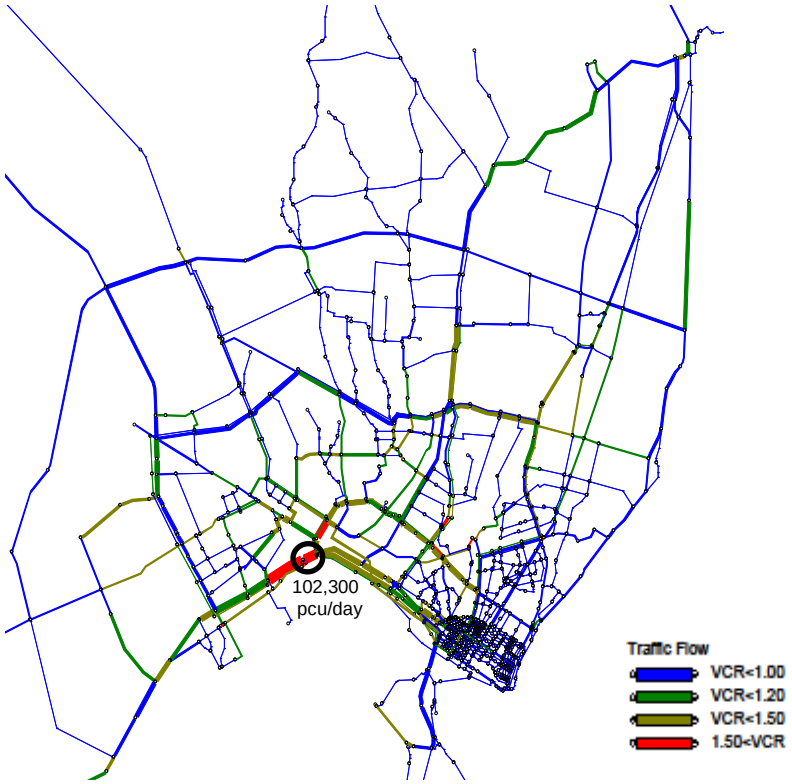
Abbreviation: VCR = Volume-Capacity Ratio
Source: JICA Project Team

Figure 6.8: Assignment of 2035 Traffic on Scenario A (Do-Minimum) Network

In Scenario B (Figure 6.9) in which a BRT network is developed, much of the congestion shown in Scenario A (the "Do Minimum" case) is eased. However, for one section of the N4 road between Maputo and Matola, the traffic volume will reach 100,000 PCU/day, and the level of congestion is expected to exceed 1.5. In addition, there are several important sections with the VCR exceeding 1.2.

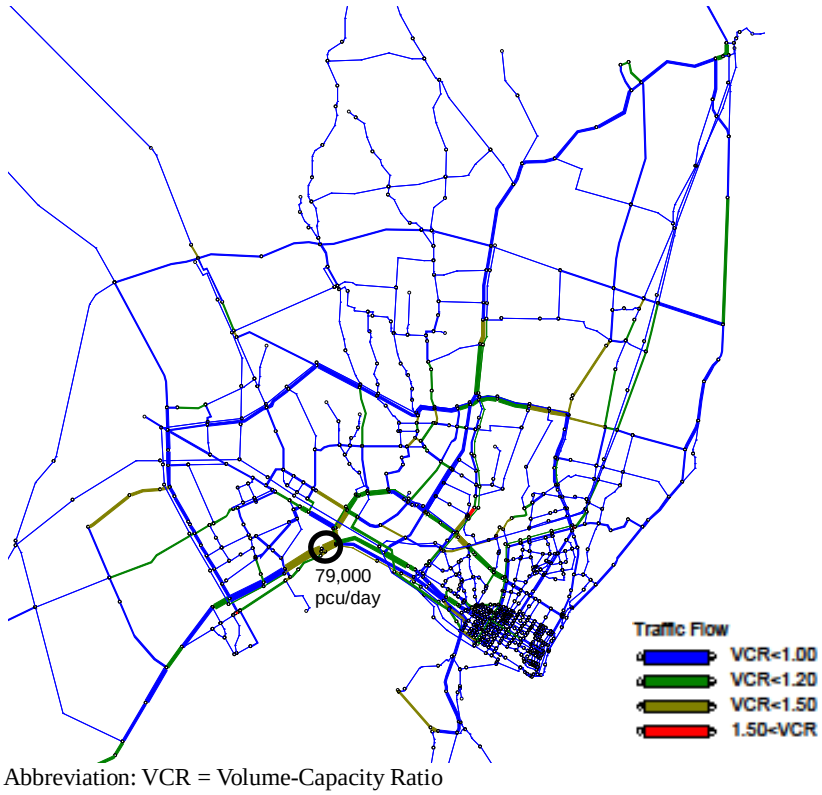
The Scenario C network (Figure 6.10), having both BRT and railway development, shows all links with congestion less than 1.5. The maximum traffic volume on N4 between Maputo and Matola is about 80,000 PCU/day, and the level of congestion at 1.2.

In terms of transport capacity, Scenario C is more desirable than Scenario B, providing a network that is not expected to cause severe congestion along most of the transport links in 2035.



Abbreviation: VCR = Volume-Capacity Ratio
Source: JICA Project Team

Figure 6.9: Assignment of 2035 Traffic on Scenario B Network



Abbreviation: VCR = Volume-Capacity Ratio
Source: JICA Project Team

Figure 6.10: Assignment of 2035 Traffic on Scenario C Network

6.5 Evaluation of Alternative Scenarios

6.5.1 System Performance Indices

Based on the transport vision and strategies and the comparison across scenarios presented in Chapter 5, system performance indices were defined as shown in Table 6.1 to enable the testing of the alternative scenarios.

Table 6.1: System Performance Indices for Scenario Evaluation

Criterion		Description and How to Compare Scenarios
(1)	Public Transport Mode Share	The percentage of passenger trips using public transport. The higher the public transport mode share the better.
(2)	Total and Average Public Transport Passenger Journey Times	Total time spent travelling by public transport, including walking and waiting times. The lower the total journey time per trip the better (i.e., total journey time divided by number of public transport trips).
(3)	Total and Average Public Transport Passenger Kilometers	Total distance of all public transport trips, inclusive of walking distances. All other things being equal, reducing passenger kilometers would be a proxy for more direct services.
(4)	Average Public Transport Journey Speed	Total passenger kilometers divided by Total Journey Time. All other things being equal, faster journeys are better than slower journeys.
(5)	Total Public Transport Vehicle Hours	Total time spent by public transport vehicles on road network in modeled day. The lower the better.
(6)	Total Public Transport Vehicle Kilometers	Total distance travelled by public transport vehicles on road network in modeled day. The lower the better.
(7)	Average Public Transport Vehicle Speed	Vehicle kilometers divided by vehicle hours. The higher the better.
(8)	Total Car Passenger Hours	Total time spent by car passengers on road network in modeled day. The lower the better.
(9)	Total Car Passenger Kilometers	Total distance travelled by car passengers on road network in modeled day. The lower the better.
(10)	Average Car Speed	Passenger kilometers divided by passenger hours. The higher the better.
(11)	Vehicle Operating Costs (Car, Truck, Bus, Chapa)	Total of vehicle operating costs of all vehicles on the road network. Described in more detail in Chapter 11. The lower the better.
(12)	Resettlement Costs	Measured by the number of people affected. The lower the better.
(13)	CO_2 Emissions	Calculated in the transport model based upon equations to convert vehicle speeds and distances into emissions. The lower the better.

Source: JICA Project Team

6.5.2 Estimation of Indices

Table 6.2 presents the estimates of the system performance indices set out above. There is a significant improvement in system performance by introducing BRT network as proposed in Scenario B in terms of key indices, for example, average public transport vehicle speed, average passenger car speed, total vehicle operating costs, and CO_2 emissions. The estimates of these indices as well as others even improve fairly substantially for Scenario C with the introduction of commuter rail systems.

Table 6.2: Estimates of System Performance Indices

Criterion	A (Do Minimum)	B	C
Public Transport Mode Share	64%	65%	72%
Average Public Transport Passenger Journey Times	45.2	26.5	31.5
Average Public Transport Passenger Kilometers	10.2	17.3	23.8
Average Public Transport Journey Speed	13.5	39.3	45.4
Total Public Transport Vehicle Hours	1,951,453	1,234,555	1,264,464
Total Public Transport Vehicle Kilometers	144,117	33,853	29,466
Average Public Transport Vehicle Speed	13.5	36.5	42.9
Total Car Passenger Hours	1,170,861	454,409	336,364
Total Car Passenger Kilometers	19,507,889	18,733,692	15,109,490
Average Car Speed	16.7	41.2	44.9
Vehicle Operating Costs (Car, Truck, Bus, Chapa)	124,664,425	76,957,549	72,511,062
Resettlement Costs	0	2110	2641
CO_2 Emissions	10,810,722	6,333,086	5,437,594

Source: JICA Project Team

6.5.3 Scoring of Alternative Scenarios

Based on the estimates obtained above, scoring of different scenarios was conducted by means of a Balanced Score Card, as set out in Table 6.3, thereby enabling different criteria developed in a multi-criteria assessment framework to be scored and combined, in order to identify the preferred scenario.

Table 6.3: Scoring for System Performance Indices

Criterion	Weighting	Scoring (0 to 100)
Public Transport Mode Share	**15%**	100 for 100% public transport passengers; 0 for 0%. Other values scaled accordingly.
Total and Average Public Transport Passenger Journey Times	**15%**	Maximum saving scored 100 and other values scaled accordingly.
Total and Average Public Transport Passenger Kilometers	**5%**	Same as above.
Average Public Transport Journey Speed	**5%**	Highest speed scores 100; lowest speed 0. Other values scaled accordingly.
Total Public Transport Vehicle Hours	**5%**	Maximum saving scored 100 and other values scaled accordingly.
Total Public Transport Vehicle Kilometers	**5%**	Same as above.
Average Public Transport Vehicle Speed	**5%**	Highest speed scores 100; lowest speed 0. Other values scaled accordingly.
Total Car Passenger Hours	**5%**	Maximum saving scored 100 and other values scaled accordingly.
Total Car Passenger Kilometers	**5%**	Same as above.
Average Car Speed	**5%**	Highest speed scores 100; lowest speed 0. Other values scaled accordingly.
Vehicle Operating Costs (Car, Truck, Bus, Chapa)	**15%**	Maximum saving scored 100 and other values scaled accordingly.
Resettlement Costs	**5%**	100 for no resettlement; 0 for most resettlement. Other values scaled accordingly
CO_2 Emissions	**10%**	100 for lowest emissions; 0 for highest emissions. Other values scaled accordingly
Total	**100%**	**100 as theoretical maximum score after weighting is applied**

Source: JICA Project Team

Table 6.4 shows the input values that are the estimates obtained above, and the scenarios scored 100 and 0. These were then converted into scores as shown in Table 6.5. Following the application of weightings to these scores, the final ranking of alternatives was as follows.

- Scenario C was identified as the preferred Scenario, with a score of 86
- Scenario B ranked second, with a score of 69
- Scenario A ("Do Minimum") ranked third (and bottom), with a score of 10

Scenario C is ranked first among these scenarios.

Table 6.4: Scoring of Input Values

	Input Values			Score 100	Score 0
Criterion	**A**	**B**	**C**	**for**	**for**
Public Transport Mode Share	64%	65%	72%	C	Do Minimum
Average Public Transport Passenger Journey Times	45.2	26.5	31.5	B	Do Minimum
Average Public Transport Passenger Kilometers	10.2	17.3	23.8	Do Minimum	C
Average Public Transport Journey Speed	13.5	39.3	45.4	C	Do Minimum
Total Public Transport Vehicle Hours	1,951,453	1,234,555	1,264,464	B	Do Minimum
Total Public Transport Vehicle Kilometers	144,117	33,853	29,466	C	Do Minimum
Average Public Transport Vehicle Speed	13.5	36.5	42.9	C	Do Minimum
Total Car Passenger Hours	1,170,861	454,409	336,364	C	Do Minimum
Total Car Passenger Kilometers	19,507,889	18,733,692	15,109,490	C	Do Minimum
Average Car Speed	16.7	41.2	44.9	C	Do Minimum
Vehicle Operating Costs (Car, Truck, Bus, Chapa)	124,664,425	76,957,549	72,511,062	C	Do Minimum
Resettlement Costs	0	2110	2641	Do Minimum	C
CO_2 Emissions	10,810,722	6,333,086	5,437,594	C	Do Minimum

Source: JICA Project Team

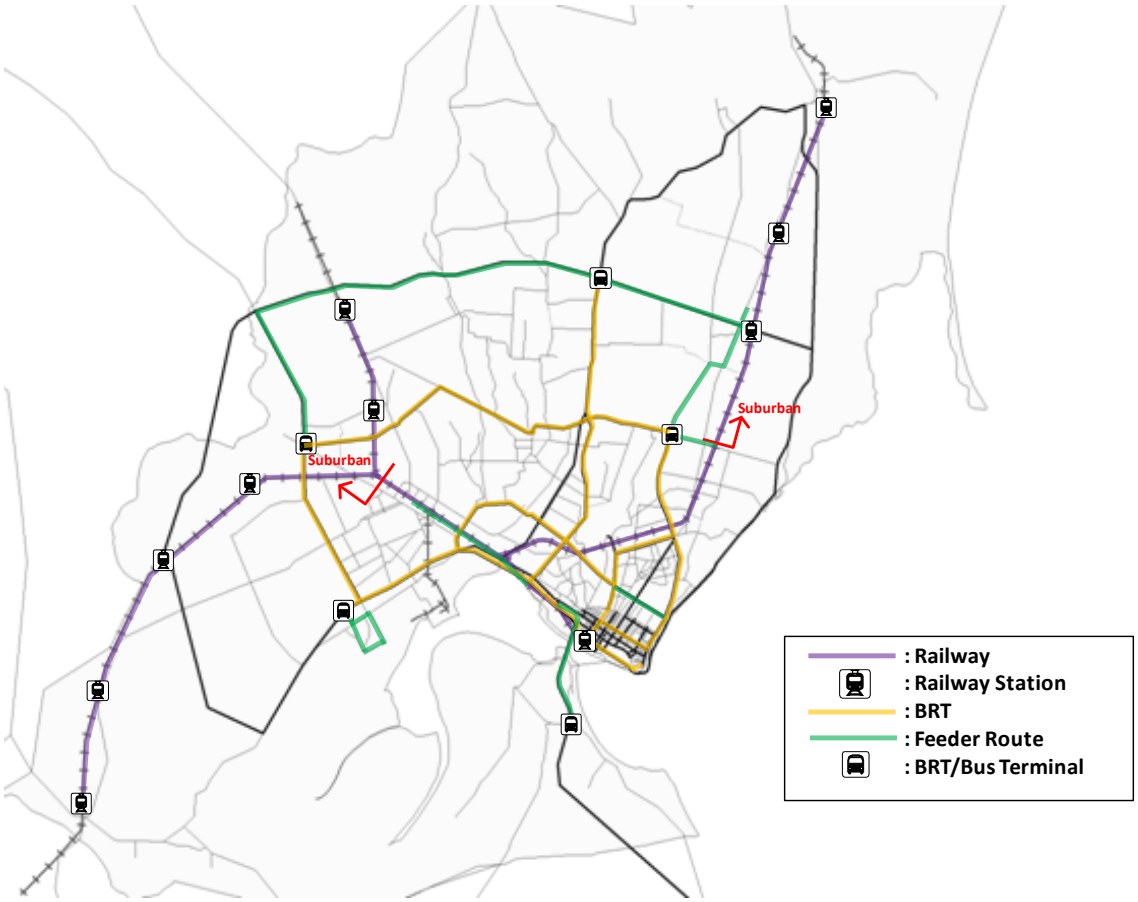
Table 6.5: Scoring of Alternative Scenarios

	Unweighted Score (0–100)				Weighted Scores		
Criterion	**A**	**B**	**C**	**Weighting**	**A**	**B**	**C**
Public Transport Mode Share	0	12	100	**15%**	0.0	1.7	15.0
Average Public Transport Passenger Journey Times	0	100	73	**15%**	0.0	15.0	11.0
Average Public Transport Passenger Kilometers	100	48	0	**5%**	5.0	2.4	0.0
Average Public Transport Journey Speed	0	81	100	**5%**	0.0	4.0	5.0
Total Public Transport Vehicle Hours	0	100	96	**5%**	0.0	5.0	4.8
Total Public Transport Vehicle Kilometers	0	96	100	**5%**	0.0	4.8	5.0
Average Public Transport Vehicle Speed	0	78	100	**5%**	0.0	3.9	5.0
Total Car Passenger Hours	0	86	100	**5%**	0.0	4.3	5.0
Total Car Passenger Kilometers	0	18	100	**5%**	0.0	0.9	5.0
Average Car Speed	0	87	100	**5%**	0.0	4.3	5.0
Vehicle Operating Costs	0	91	100	**15%**	0.0	13.7	15.0
Resettlement Costs	100	20	0	**5%**	5.0	1.0	0.0
CO_2 Emissions	0	83	100	**10%**	0.0	8.3	10.0
Total				**100%**	**10**	**69**	**86**
Final Ranking					**3**	**2**	**1**

Source: JICA Project Team

6.5.4 Master Plan Transport Network

Based on the comparison of the alternative scenarios made in this section and in Chapter 5, Scenario C is selected as the preferred transport network shown in Figure 6.11, which is taken forward for setting out Master Plan projects and programs in the subsequent chapters.



Source: JICA Project Team

Figure 6.11: Preferred Transport Network

Chapter 7 Road Network Improvement Plan

7.1 Introduction

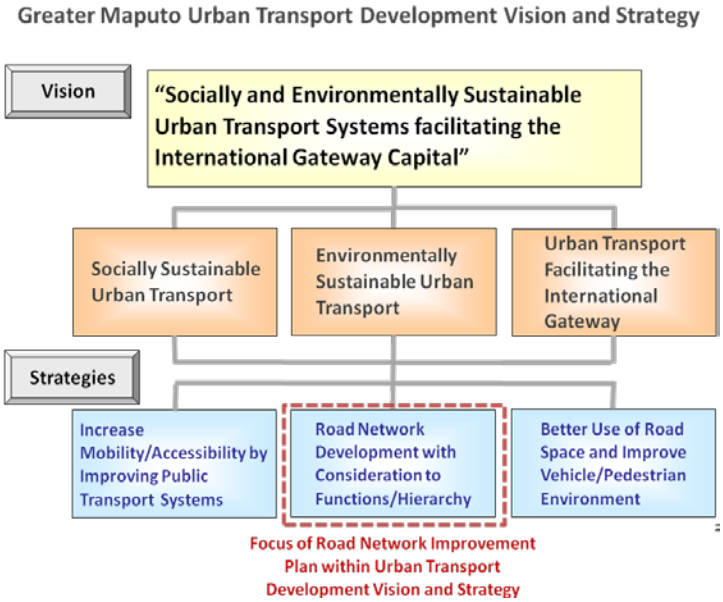
A road network, one of the most basic forms of infrastructure that make up the urban character, is a crucial element for sustainable growth of urban areas. In Greater Maputo, urbanization is quickly expanding from the central urban area; however, the development of the road network has not kept up with the current growing demand. In particular, chronic traffic congestion is caused by the lack of arterial roads running through the urban core and by the insufficient road connections to the regions of Greater Maputo. As shown in the development scenario in the preceding chapter, based on the trends of future traffic, population, and land use, the systematic and continuous development of the road network is necessary for sustainable growth.

This chapter clarifies the function and classification of roads, and proposes an effective road network development plan including its development process.

7.2 Policies and Strategies

7.2.1 Role of the Road Network Improvement Plan within the Comprehensive Urban Transport Strategy

As outlined in Figure 7.1 below, the Road Network Improvement Plan has an important play in delivering the Greater Maputo comprehensive urban transport development vision and strategy. The overarching vision of "socially and environmentally sustainable urban transport systems facilitating the international gateway capital" is underpinned by three comments: i) socially sustainable urban transport; ii) environmentally sustainable urban transport; and iii) urban transport facilitating the international gateway – all of which will depend on the delivery of three strategies. One of these is "road network development with consideration to functions/hierarchy" which, as shown in the figure below, provides the focus for this road network development plan. As also shown, the road network development plan will be supported by an integrated strategy alongside public transport and traffic management (better use of existing road space).



Source: JICA Project Team

Figure 7.1: Role of the Road Network Improvement Plan within the Urban Transport Development Vision and Strategy

7.2.2 Road Development Strategies

While national roads (e.g., N1 and N4) have been developed continuously, the municipal and district roads in Maputo, Matola, Marracuene, and Boane are insufficient as arterial road networks and have poor road surface conditions. Also, roads in urban areas are chronically congested.

Road development policy requires considering the current situation, land use development plan, and transport demand, through SC meetings and workshops. Road development in recent years has been inadequate in meeting traffic demand which has been caused by the growing number of vehicles due to the expansion of industrial and residential areas. As noted, urban roads are heavily congested, and traffic between districts in suburban areas also require attention. Also, road development must take into account potential natural disasters (e.g., floods) exacerbated by rapid urbanization. It is expected that the road network development strategies set out in Chapter 5 and the Scenario C transport network selected as a preferred option in Chapter 6 will contribute effectively to resolving these transport problems.

In addition, the road development in Greater Maputo should adequately address the major transport issues/challenges summarized in subsection 2.3.1 including the transport development along Maputo–Matola (East-West Axis) and the North-South Axis. In order to implement these developments, road development plans should include the development initiatives described in subsection 5.3.2 which are needed urgently to address the major transport issues/challenges.

7.2.3 Road Classification

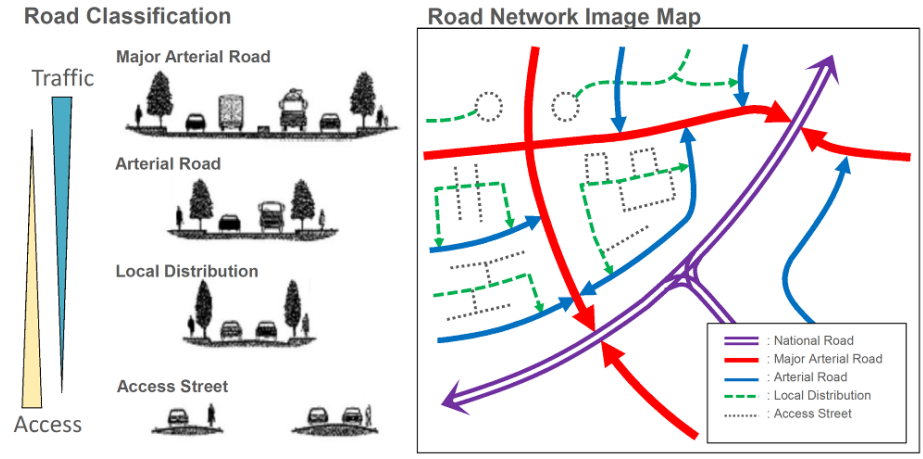
Roads are a space for the movement of people and goods. They have various functions, such as providing access to urban residential space and assisting in disaster prevention. There is a tradeoff between the traffic and access functions, which should be considered based on traffic characteristics and land use. Although ANE's roads and Maputo's roads each have its different road classifications, in other surrounding areas there is no road classification that is applied. In order to plan a systematic future road network, a unified road classification system is important.

The road classification for this Master Plan is outlined for the local road network. Table 7.1 presents the road classification system, while Figure 7.2 presents the urban road hierarchy.

Table 7.1: Road Classification for an Effective Road Network

Road Classification	Functions
Major Arterial Road	Major arterial roads (including national roads) are constructed to provide an urban framework. They are important routes with heavy traffic volumes.
Arterial Road	Arterial roads connect different regions and serve major urban facilities.
Local Distributor Road	Local distributor roads allow for entry into and exit from a district. They should eliminate through traffic.
Access Street	Access streets provide access to residences and facilities in a district. The travel speed of vehicles on access roads should be controlled.
Special/Other Roads	Examples of special roads include pedestrian roads and roads in shopping malls.

Source: JICA Project Team



Source: JICA Project Team

Figure 7.2: Urban Road Network Hierarchy

7.2.4 Road Network Development

This section presents strategies for arterial road network development in Greater Maputo to be undertaken by 2035. These strategies were developed based on the following considerations:

- Current traffic conditions and major issues/challenges identified in Chapter 2 based on various traffic surveys conducted during this study
- Road network development strategies and alternative transport network options set out in Chapter 5 together with the corresponding land use scenarios
- Results of the traffic assignment for the alternative transport network options and the selection of Scenario C as a preferred network option undertaken in Chapter 6
- Need for developing an effective road network considering the network hierarchy as described in the preceding subsection

(1) Major Arterials

Although national roads (e.g., N1 and N4) have been systematically developed in Maputo, the traffic capacity in urban areas is already saturated. Local roads – the connecting roads between districts and major arterial roads – are insufficient. There are an insufficient number of major arterial roads that are complementary to national roads. Also, there are roads with missing or incomplete sections and roads with poor surfaces. Major arterial roads form the basic structure of the urban road network and has high traffic volumes as shown in the preceding section. Based on trends and the land use plan, the urban area is expected to expand, and this should be taken into account in planning for major arterial roads, e.g., by providing for traffic distribution via distributor roads, connecting roads between districts, and increasing traffic capacity through roadway widening and pavement improvement. The major arterial road network for the future is proposed by evaluating the existing road network, and by integrating the results from the traffic survey and transport demand forecasting for future land use and traffic scenarios.

Strategies for major arterial roads development include the following.

- Development of major arterial roads along the North-South Axis
- Development/improvement of major arterial roads between Maputo and Matola (along the East-West Axis), including the inner and outer ring roads and the industrial roads linked to the Matola industrial area
- Improvement of other major arterial roads, including N1 widening and new N1 bypass construction which are part of the transport development along the North-South Axis

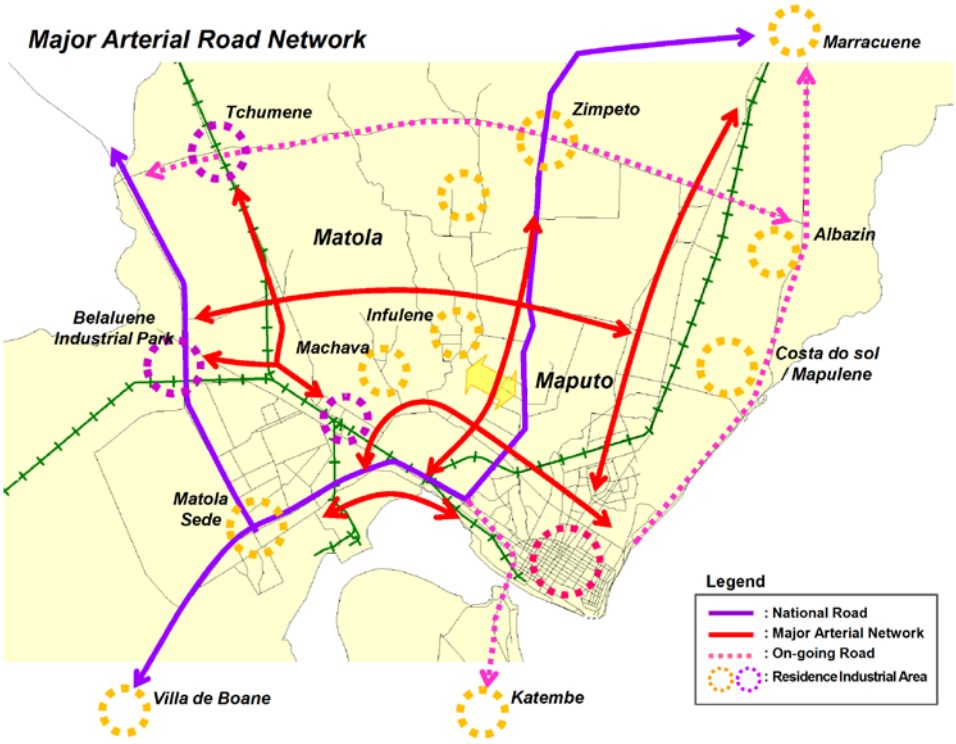
Table 7.2 presents the details of each of the strategies.

Table 7.2: Major Arterial Road Development Strategy

Major Arterial Development Strategy		Details
1	Maputo north-south major arterial road	• Airport Side North-South Route New Construction • Julius Nyerere Rehabilitation • Julius Nyerere Improvement • Eastern Airport North-South Route Improvement • Maputo Central Urban Area Major Arterial Road Four-lane Widening • Maputo–Marracuene Connection Road Improvement (A) • Maputo–Marracuene Connection Road Improvement (B)
2	Ring road and east-west major arterial road	• Outer Ring Road New Construction • Inner Ring Road New Construction • Matola Av. Eduardo Mondlane Widening • Boane Outer Ring Road New Construction and N2 Widening
3	Western Matola Industrial Area major arterial road	• Industrial Road Improvement • N4 Widening
4	National road and other major arterial road	• KaTembe Bridge Development • N1 Widening (South) • N1 Widening (North) • New N1 Bypass Construction • Boane Bridge Reconstruction

Source: JICA Project Team

Figure 7.3 presents development strategies for the major arterial road network.



Source: JICA Project Team

Figure 7.3: Development Strategies for Arterial Road Network

(2) Arterial Roads within Districts and between Districts

The road network within districts and between districts is insufficient as there are unfinished roads, causing severe traffic congestion at particular road sections. To alleviate the current congestion, distributing traffic or increasing traffic capacity would be inevitable. Residential and industrial areas are planned to be extended to suburban areas, and a road network which only connects between districts cannot sufficiently meet the demand of the expected increase in traffic volume. Arterial roads are important as they connect districts and main urban facilities as shown in the preceding section. To effectively facilitate community development, the provision of new roads which run through these districts and provide easy access to urban facilities is vital. The future arterial road network is proposed based on the evaluation of the existing road network, traffic survey results, and transport demand forecasting of this project for future land use and traffic scenario.

Strategies for arterial road development include development of the following.

- District-framing arterial road
- Detour arterial road for traffic distribution
- Connection arterial road between districts
- Land use-inducing arterial road

Table 7.3 presents the details of each of the strategies.

Table 7.3: Arterial Road Development Strategy

Arterial Development Strategy		Details
5	District-framing arterial road	• Nhlamankulu Area Route Improvement and New Construction • Eastern Airport Urban Area Route Improvement • Northern Maputo East-West Route Improvement • Infulene Urban Area Road Improvement • Machava Urban Area New Construction and Improvement • Matola Suburban Area New Construction and Improvement • Matola–Sede Urban Arterial Road Improvement • KaTembe R403 Improvement
6	Detour arterial road for traffic distribution	• Maputo Central Urban Area Peripheral Road Four-Lane Widening • Western Airport Area Route Improvement • Green Belt Road Improvement and New Construction • Matola Power Cable Line Extension New Road Construction
7	Connection arterial road between districts	• Machava–Maputo Connection New Road Construction and Improvement • Infulene–Maputo Connection New Road Construction and Improvement • Northern Infulene–Maputo Connection Road Improvement
8	Land use-inducing arterial road	• Costa do Sol Area New Road Network Construction for District Development • Northern Matola Area New Road Construction for District Development • Marracuene East-West Route New Construction • Boane Connection New Road Construction for District Development • Boane–KaTembe Connection New Road Construction for District Development

Source: JICA Project Team

7.3 Road Improvement Plans

7.3.1 Road Network Projects

(1) List of Road Improvement Projects for 2035

The road network plan is developed based on traffic survey results and transport demand forecasting in 2035 towards the development policy of the major arterial roads and arterial roads as described in the preceding section. A long list of road network projects (Table 7.4 and Figure 7.4) is provided by selecting candidate projects based on the inventory survey results, existing plan, and the questionnaire survey results conducted in the workshop and road sector working group meeting. The road network plan was formulated in consideration of environmental impacts such as the relocation of houses and trees, and recommends the use of existing roads as much as possible. Ongoing projects were also included in the long list. The number of lanes is evaluated based on the future traffic volume and the vehicle capacity ratio in 2035; and the cross section component is proposed based on the consideration of traffic function, roadside environment, and the right of way.

Table 7.4: List of Road Improvement Projects for 2035

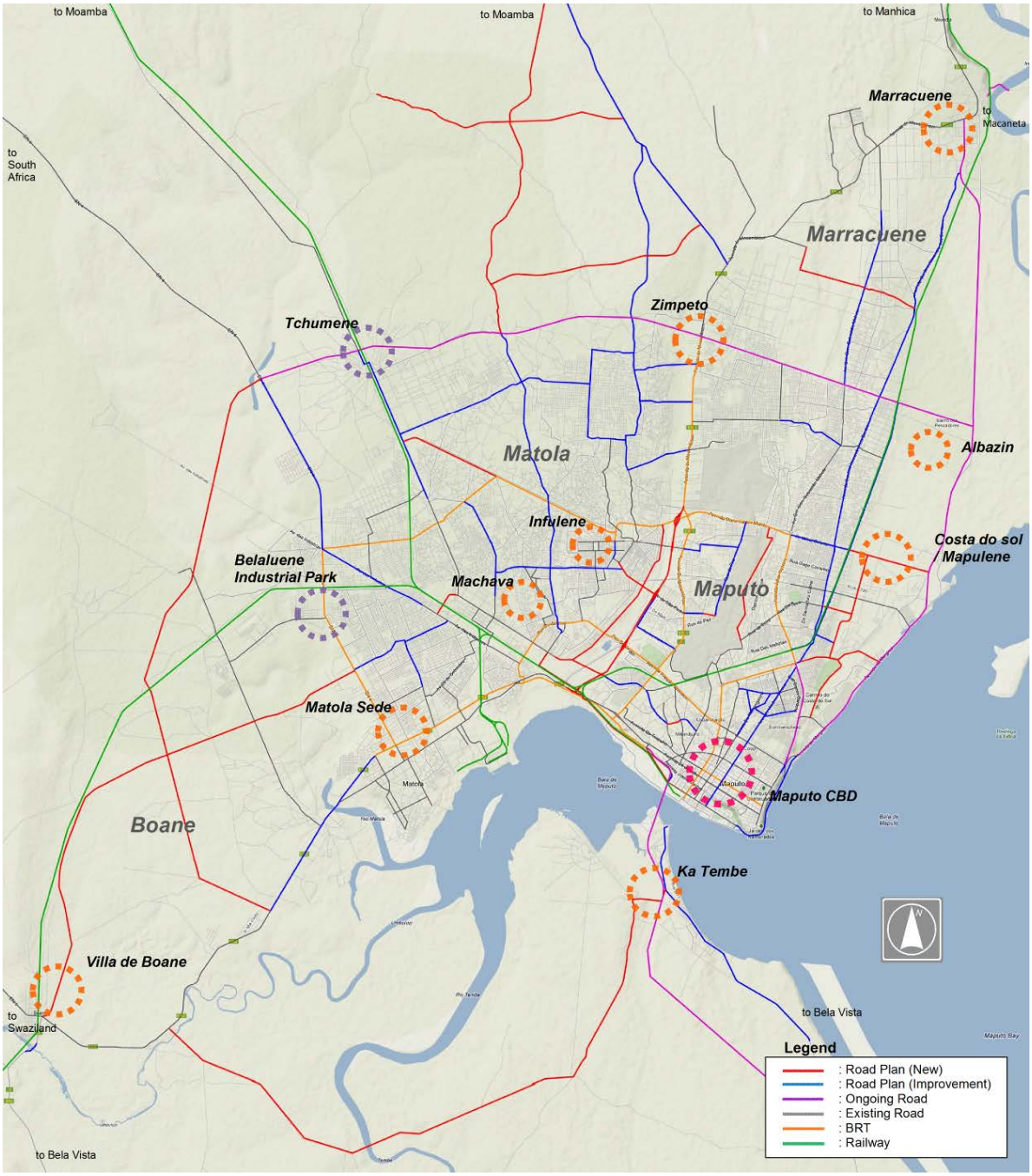
No.	Project Component	Route	Length (km)	Lane Number	Project Type	Remarks
1. Maputo North–South Major Arterial Roads						
1.1	Airport Side North–South Route New Construction	Extension of Rua do Mercado	4.8	2	New	
1.2	Julius Nyerere Rehabilitation	Julius Nyerere (South)	3.6	4	4-lane	Ongoing
1.3	Julius Nyerere Improvement	Julius Nyerere (North)	N/A	N/A	N/A	Missing Number for BRT (No.9.2)
1.4	Eastern Airport North-South Route Improvement	Rua da Igreja	10.3	2	Paving	
1.5	Maputo Central Urban Area Major Arterial Road Four-lane Widening	Av. Vladimir Lenine	6.2	4	4-lane	
1.6	Maputo–Marracuene Connection Road Improvement (A)	• Av. Cardeal Alexandre dos Santos • Rua 4.665	19.3	2	Widening / paving	
1.7	Maputo - Marracuene Connection Road Improvement (B)	• Extension of Av. Coronel General Sebastiao Mabote • Extension of Av. Coronel General Sebastiao Mabote (Northern)	6.7	2	Widening /new construction	
2. Ring Roads and East-West Major Arterial Roads						
2.1	Outer Ring Road New Construction	I: Radisson Hote–Costa del Sol Bridge II: Costa del Sol Bridge–Chiango III: Chiango–Zinpeto National Stadium IV: Marracuene–Zinpeto National Stadium V: Zinpeto National Stadium–Bairro Tchumene VI: Machava–June 16 Square	74.0	4	4-lane / new	Ongoing
2.2	Inner Ring Road New Construction	• Extension of New Inner Ring Road • Rua Mário Coluna	5.2	2	New / Widening	BRT (No.9.7)

No.	Project Component	Route	Length (km)	Lane Number	Project Type	Remarks
2.3	Matola Av. Eduardo Mondlane Widening	Av. Eduardo Mondlane/ Matola	N/A	N/A	N/A	Missing Number for BRT (No.9.4)
2.4	Boane Outer Ring Road New Construction and N2 Widening	• Extension of Ring Road • N2	30.6	4	New / 4-lane	
3. Western Matola Industrial Area Major Arterial Roads						
3.1	Industrial Road Improvement	• Rua 21.115, Rua 21.142 • Av. das Industrias • R807 (Av. Josina Machel)	11.6	2	New / paving	
3.2	N4 Widening	N4 (North)	6.9	4	4-lane	
4. National Roads and Other Major Arterial Roads						
4.1	KaTembe Bridge Development	Maputo / KaTembe / Ponta do Ouro	2.7	4	Bridge	Ongoing
4.2	N1 Widening (South)	N1	6.5	4	4-lane	Completed
4.3	N1 Widening (North)	N1	N/A	N/A	N/A	Missing Number for BRT (No.9.3)
4.4	New N1 Bypass Construction	New N1 Bypass	8.3	4	New	
4.5	Boane Bridge Reconstruction	N200 (Boane Bridge)	0.6 (0.15)	2	Bridge	
5. District Framing Arterial Road						
5.1	New Construction and Improvement of Nhlamankulu Area Route	• Extension of Rua do Zambeze • Rua do Zambeze • Rua do Chamanculo	2.8	2	New / Paving	
5.2	Eastern Airport Urban Area Route Improvement	• Av. Da Malhangalene • Rua 1º de Maio • Rua 3.385 • Rua Tenente General Fernando Honwana, Rua José Carlos Lobo	6.0	2	Widening	
5.3	Northern Maputo East-West Route Improvement	Extension of Av. Nelson Mandela	2.6	2	Widening	
5.4	Infulene Urban Area Road Improvement	• Rua Francisco N.Matsinhe • Rua 31.236	2.2	2	Paving	
5.5	New Construction and Improvement of Road in the Machava Urban Area	• Rua Rafael Maguni • Rua 31.199, Av. Filipe Samuel Magaia • Av. 3 de Fevereiro	12.1	2	Widening /new	
5.6	New Construction and Improvement of Road in the Matola Suburban Area	• (Infulene Middle District, North-South Route) • (Infulene Middle District, Peripheral Route) • (Machava Central District, North-South Route) • (Machava Central District, East–West Route)	26.5	2	Widening	
5.7	Matola–Sede Urban Arterial Road Improvement	• Av. Joaquim Chissano/ Matola • Av. Maestro Justino Chemane	5.8	2	Paving	
5.8	KaTembe R403 Improvement	R403	10.4	2	Paving	
6. Detour Arterial Roads for Traffic Distribution						
6.1	Maputo Central Urban Area Peripheral Road Four-Lane Widening	Av. da Marginal	4.3	4	4-lane	

No.	Project Component	Route	Length (km)	Lane Number	Project Type	Remarks
6.2	Western Airport Area Route Improvement	• Rua da Paz • Rua de São Paulo • Extension of Rua de São Paulo • Rua 5.576, Rua 5.650	7.1	2	Widening / paving / new	
6.3	New Construction and Improvement of Greenbelt Road	• Extension of Rua das Quintas • Extension of Rua das Agricultores • Extension of Rua das Zonas Verdes	6.3	2	New	
6.4	Matola Power Cable Line Extension Road New Construction	New Road (Power Cable Line)	3.7	2	New	
7. Connection Arterial Road between Districts						
7.1	New Construction and Improvement of Machava–Maputo Connection Road	• Extension of Rua 5.036 • Extension of Rua 5.037	3.5	2	Widening /new	
7.2	New Construction and Improvement of Infulene–Maputo Connection Road	• Rua 5.260 • Rua 5.315 • Rua 31.286	5.7	2	Paving / widening / new	
7.3	Northern Infulene–Maputo Connection Road Improvement	Rua de Macute (Greenbelt Crossroad)	6.6	2	Paving / widening	
7.4	Exclusive Bus Road of Maputo–Matla New Construction	Maputo-Matola Railway-side	7.2	2	New	
8. Land use-inducing Arterial Road						
8.1	Costa do Sol Area Road Network New Construction for District Development	• Rua 4.280, Rua 4.664 • Extension of Rua do Rio Inhandiara, Rua 4.685, Rua 4.662, Rua 4.342	11.8	2	New	
8.2	Northern Matola Area New Road Construction for District Development	• Northern Matola North South Road • Northern Matola East-West Road • R808	51.5	2	Widening /new / paving	
8.3	Marracuene East–West Route New Construction	Marracuene East-West Route	5.3	2	New	
8.4	Boane Connection New Road Construction for District Development	Boane–Matora Rio Route	19.6	2	New	
8.5	Boane–KaTembe Connection New Road Construction for District Development	Boane–KaTembe Route, R404	25.7	2	New	
9. Improvement for BRT						
9.1	BRT Maputo Central Urban Line	Av. Eduardo Mondlane	2.6	BRT+4	paving	
9.2	BRT Maputo North-South Line	• Av. Guerra Popular • Av. Acordos de Lusaka • Av. F.P.L.M • Av. Julius Nyerere	12.4	BRT+4	paving / widening	(No. 1.3)
9.3	BRT N1 Line	• N1 (South) • N1 (North)	15.4	BRT +2 (4)	paving	(No. 4.3)
9.4	BRT Maputo Machava East–West Line	• Av. Joaquim Chissano • Av. Eduardo Mondlane / Matola	10.4	BRT+4	paving / widening	(No. 2.3)

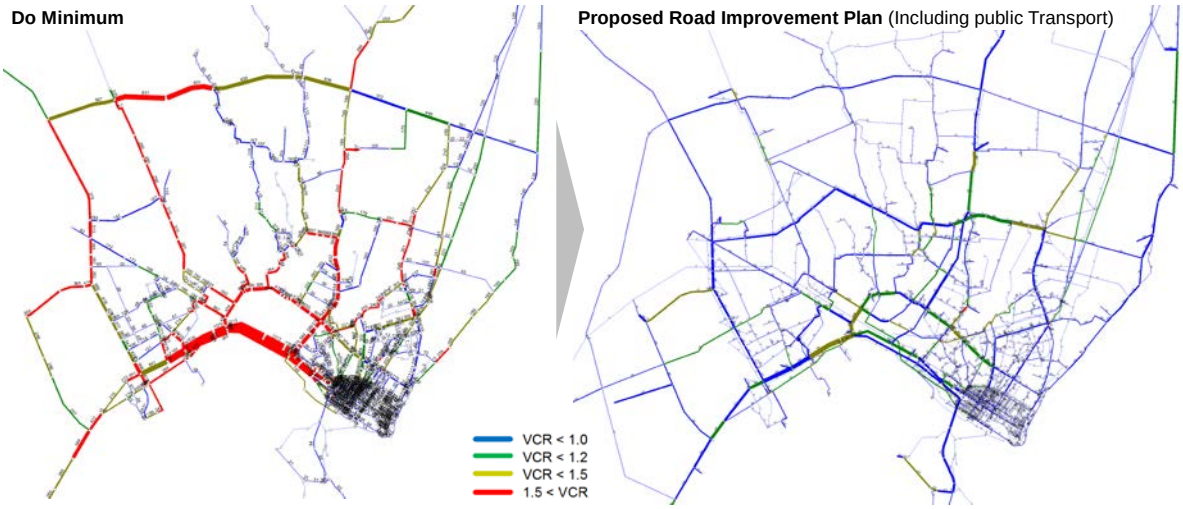
No.	Project Component	Route	Length (km)	Lane Number	Project Type	Remarks
9.5	BRT Maputo Matola Sede Line	• Av. Setembro, Av. Organização das Nações Unidas • New Ring Road VI • N4 (Matola)	14.0	BRT +4 (6)	paving / new	
9.6	BRT Matola N4 Line (South)	N4 (South)	7.9	BRT+4	paving	
9.7	BRT Inner Ring Road Line	• Av. Maria de Lurdes Mutola • New Road (Zona Verde, Power Cable Line, R807, N4)	19.3	BRT+4	Paving / new	(No. 2.2)

Source: JICA Project Team



Source: JICA Project Team

Figure 7.4: Location of Road Improvement Projects for 2035



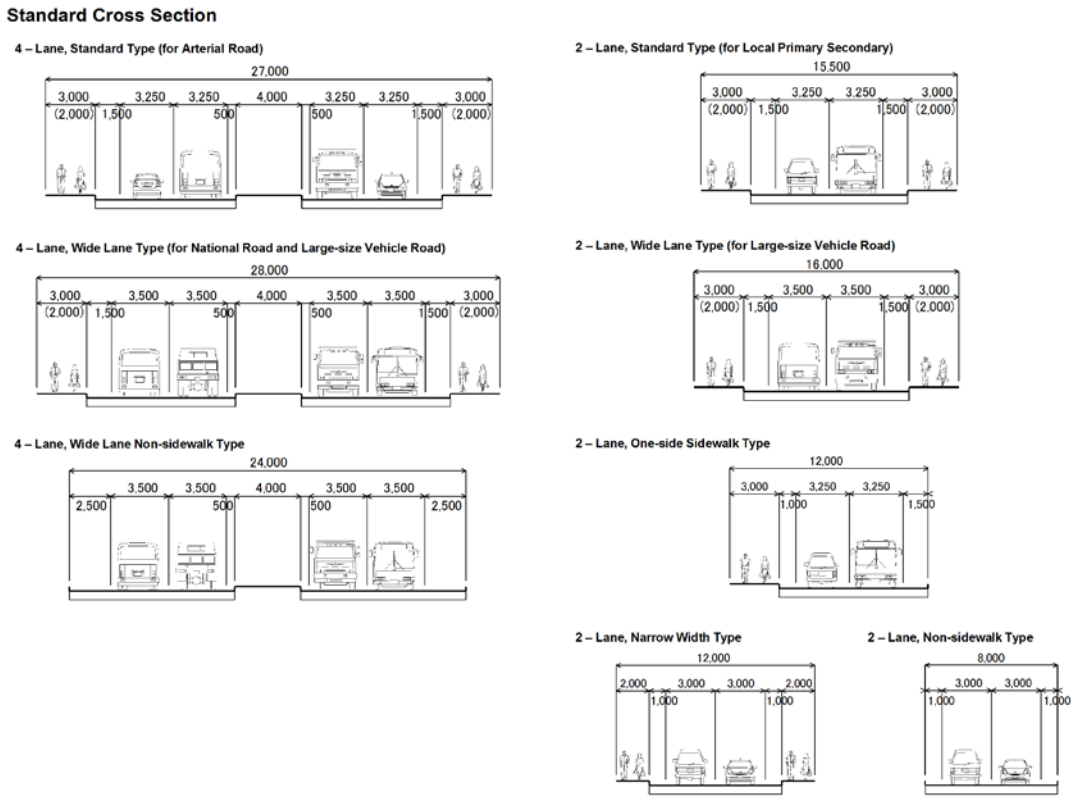
Source: JICA Project Team

Figure 7.5: Future Traffic Volume and Vehicle Capacity Ratio

(2) Standard Component of Cross-Section

The standard component of the cross-sections for the road network development plan was prepared based on the design standards of the National Roads Administration (Administração Nacional de Estradas, ANE). The number of lanes should be established based on future transport demand, and the type of cross-section (see Figure 7.6) should be established taking into consideration the road classification, traffic characteristics, road function, land use, and current road width or right-of-way. Specific considerations follow:

- Wider lane widths are adopted for routes that are used by many large-sized vehicles.
- The standard shoulder width should be 1.5 m for vehicles to make emergency stops and right turns near intersections.
- Medians should be 4 m wide to prevent serious accidents, provide for right turns, and provide for lane addition/expansion.
- Sidewalks in urban areas should be more than 3 m wide for the safety of pedestrians, the passing of carts, and the placement of road facilities, and they should be more than 2 m in other districts.



Source: JICA Project Team

Figure 7.6: Standard Component of Cross-Sections (1/2)

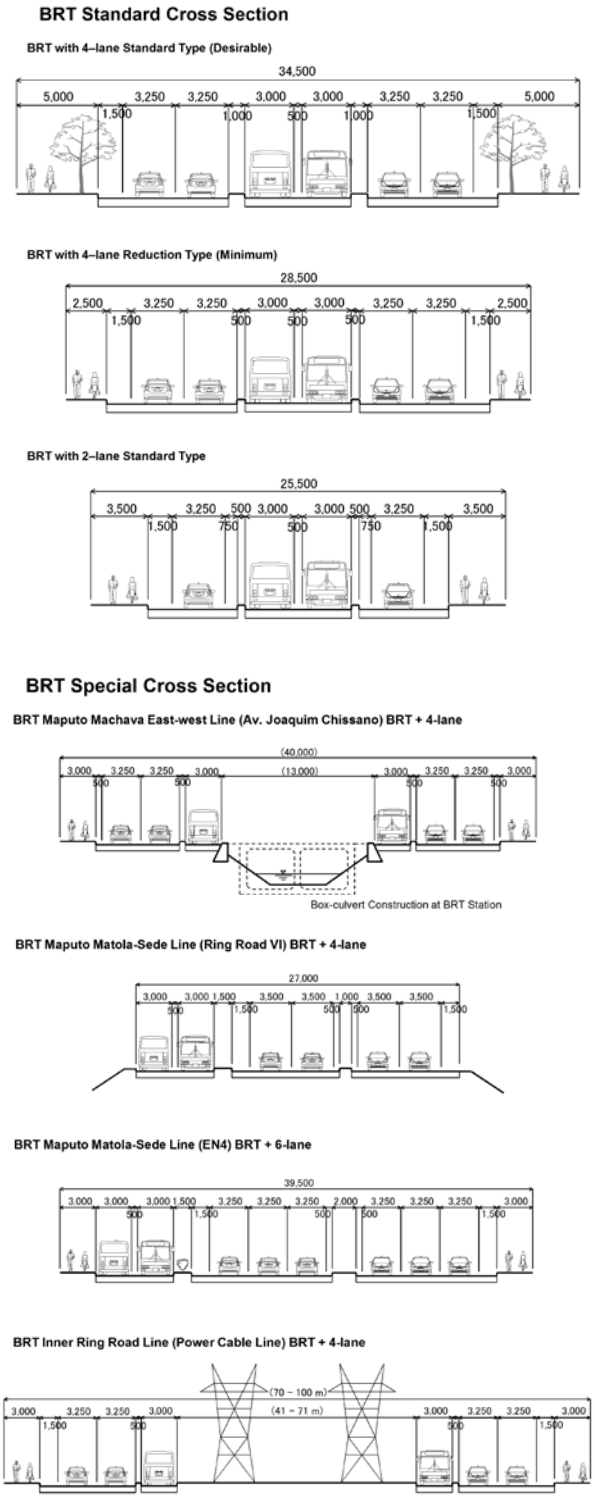
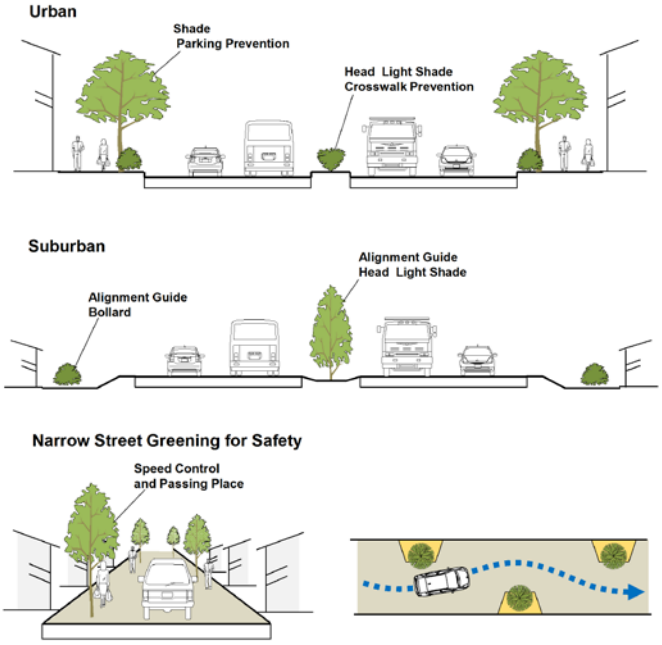


Figure 7.6: Standard Component of Cross-Sections (2/2)

(3) Road Greening

In urban areas, "road greening" is recommended to improve the urban landscape, enrich the living environment, and enhance traffic safety. In suburban areas, road greening is required to provide a safer and more comfortable driving environment, e.g., through the use of delineators. Road greening concepts are shown in Figure 7.7.



Source: JICA Project Team

Figure 7.7: Road Greening Concepts

7.3.2 Future Pavement Ratio

An evaluation index was specified taking into account the proportion of paved roads after the development of the road network. The "target pavement ratio" is based on the existing road development and the proposed road network length. Target pavement ratios and road densities/ pavement ratios are shown in Tables 7.5 and 7.6.

Table 7.5: Target Pavement Ratios

District	2013	2035
Maputo, Matola	32%–36%	50%
Marracuene, Boane	15%–16%	35%

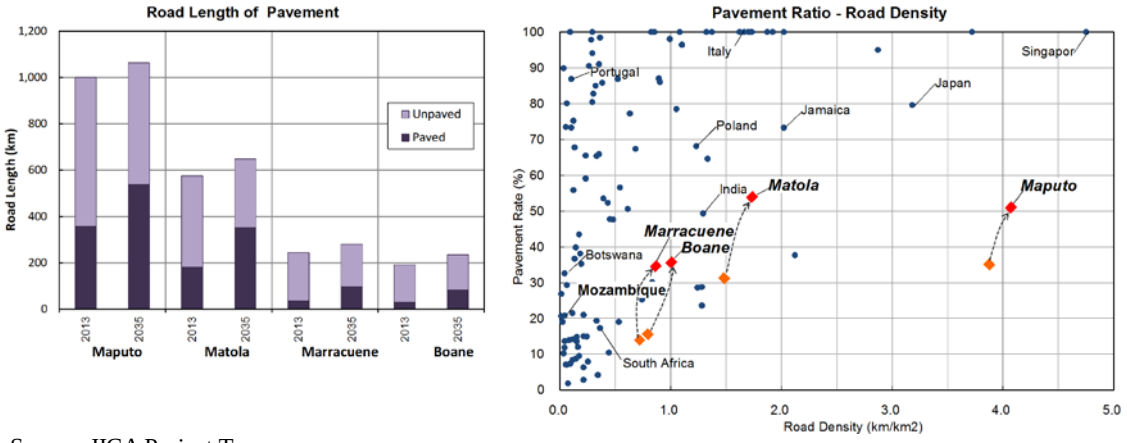
Source: JICA Project Team

Table 7.6: Road Densities and Pavement Ratios

	Area (km^2)	Year	Length (km)	Paved (km)			Unpaved (km)	Road Density (km/km^2)	Pavement Ratio (%)
				Total	New	Existing			
Maputo	262	2013	1,001	359	---	---	642	3.83	35.9
		2035	1,063	537	118	60	526	4.07	50.5
Matola	391	2013	576	182	---	---	394	1.47	31.6
		2035	648	351	159	10	297	1.66	54.2
Marracuene	348	2013	244	35	---	---	208	0.70	14.5
		2035	281	97	51	10	184	0.81	34.4
Boane	259	2013	193	31	---	---	161	0.74	16.3
		2035	235	84	42	10	151	0.91	35.7

Source: JICA Project Team

Figure 7.8 shows the relationship between paved and unpaved road length, and the pavement ratio and road density, in various locations in the study area.



Source: JICA Project Team

Figure 7.8: Road Length and Pavement Ratio – Road Density

7.3.3 Phasing of Road Development

(1) Factors Considered

A program of phased development was designed considering various factors such as importance, technical impacts, socioeconomic impacts, environmental impacts, and consistency with related projects (e.g., BRT). Phasing is quantitatively evaluated based on future traffic volume, environmental evaluation, and discussion results from road sector working group meetings. Table 7.7 presents the evaluation. Ongoing projects were not evaluated.

Table 7.7: Factors and Weights for Phasing

	Importance	**Technical Effect**	**Socioeconomic Impacts**	**Environmental Impacts**	**Consistency with Related Projects**
	- Traffic Volume - Area	- Traffic - Land Use	- Project Cost	- Resettlement	- Related Plans
Weight	25%	20%	20%	25%	10%
5	Large/Urban	High/High	Very Low	Very Low	Yes (Very Important)
4	Large/Suburban Medium/Urban	High/Low	Low	Low	N/A
3	Medium/Suburban	Medium/High	Medium	Medium	Yes (Important)
2	Small/Urban	Medium/Low	High	High	N/A
1	Small/Suburban	Low/Low	Very High	Very High	N/A

Source: JICA Project Team

(2) Evaluation Result

The list of projects is divided into short, medium, and long-term development plans, as follows:

Short Term:
- High score
- High urgency

Medium Term:
- Medium score
- Large resettlement impact in cases with high evaluation

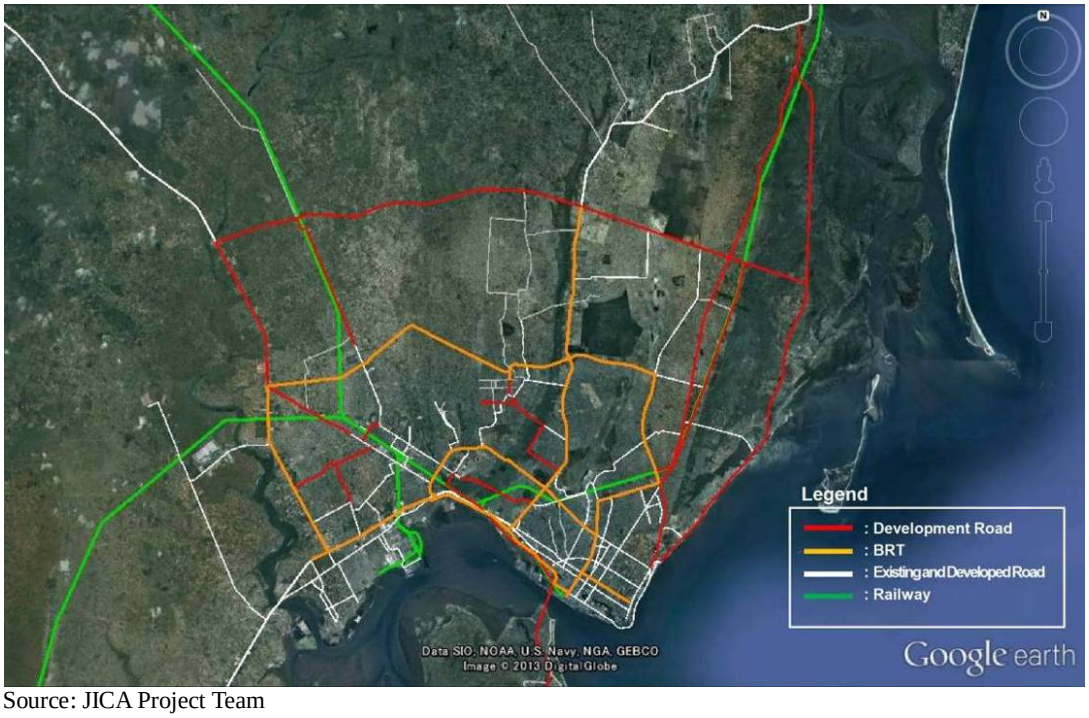
Long Term:
- Low score
- Outside the project area road network

The results of the scoring and phasing of the road network development are shown in Tables 7.8, 7.9, 7.10, and Figures 7.9, 7.10, and 7.11, for 2018, 2025, and 2035, respectively.

Table 7.8: Phasing of Road Network Development for 2018

No.	Project Component	Length (km)	Number of Lanes	Project Type	Ranking based on Scoring	Proposed Term	Remarks
1.6	Maputo–Marracuene Connection Road Improvement (A)	19.3	2	Widening/ Paving	6	Short	
3.1	Industrial Road Improvement	11.6	2	New/ paving	9	Short	
3.2	N4 Widening	6.9	4	4-lane	2	Short	
4.4	New N1 Bypass Construction	8.3	4	New	2	Short	
4.5	Boane Bridge Reconstruction	0.6	2	Bridge	18	Short	Urgent
5.4	Infulene Urban Area Road Improvement	2.2	2	Pave	5	Short	
5.7	Matola–Sede Urban Arterial Road Improvement	5.8	2	Pave	2	Short	
7.1	New Construction and Improvement of Machava–Maputo Connection Road	2.8	2	Widening / new	6	Short	
7.2	New Construction and Improvement of Infulene–Maputo Connection Road	5.7	2	Paving / widening/ new	6	Short	
7.4	Exclusive Bus Road of Maputo–Matla New Construction	7.2	2	New	1	Short	
Improvement for BRT							
9.1	BRT Maputo Central Urban Line	2.6	BRT+4	Paving	N/A	Short	
9.2	BRT Maputo North-South Line	12.4	BRT+4	Paving / widening	N/A	Short	No.1.3
9.3	BRT N1 Line	15.4	BRT+2 (4)	Paving	N/A	Short	No.4.3

Source: JICA Project Team



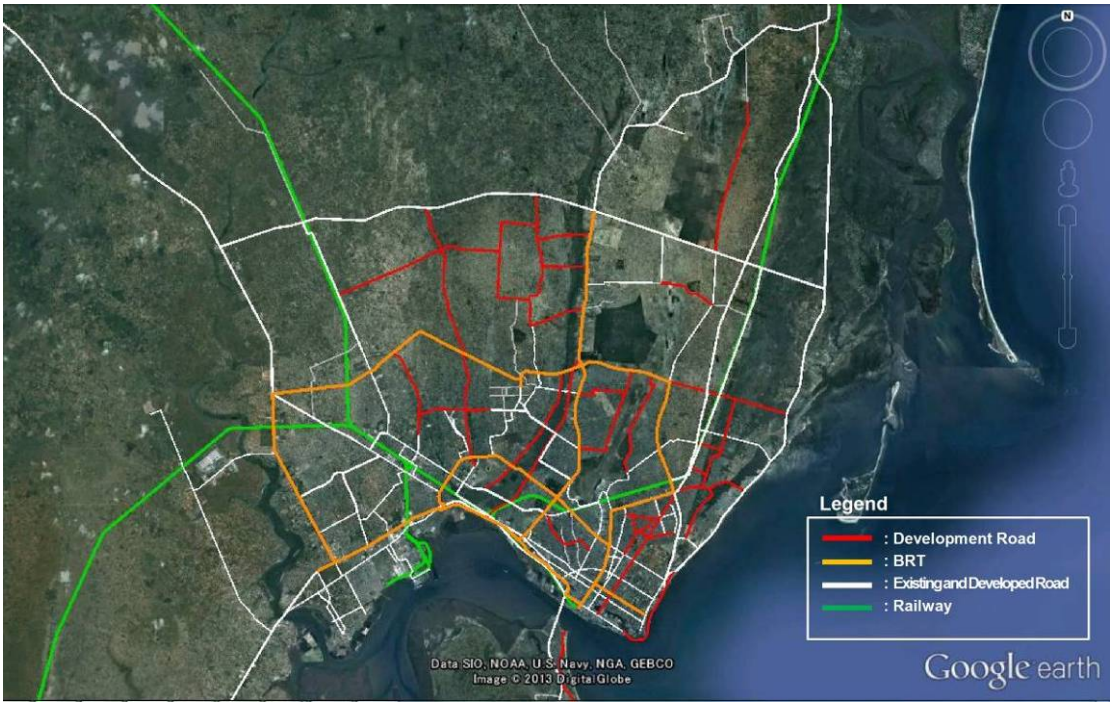
Source: JICA Project Team

Figure 7.9: Road Network in 2018

Table 7.9: Phasing of Road Network Development for 2025

No.	Project Component	Length (km)	Number of Lanes	Project Type	Ranking based on Scoring	Proposed Term	Remarks
1.1	Airport Side North–South Route New Construction	4.8	2	New	23	Medium	
1.4	Eastern Airport North–South Route Improvement	10.3	2	Paving	11	Medium	
1.5	Maputo Central Urban Area Major Arterial Road Four-Lane Widening	6.2	4	4-lane	10	Medium	
1.7	Maputo–Marracuene Connection Road Improvement (B)	6.7	2	Widening / new	20	Medium	
2.2	New Construction of Inner Ring Road	5.2	2	New / widening	16	Medium	Considerable resettlement
5.1	New Construction and Improvement of Nhlamankulu Area Route	2.8	2	New / paving	16	Medium	
5.2	Eastern Airport Urban Area Route Improvement	6.0	2	Widen	23	Medium	
5.3	Northern Maputo East–West Route Improvement	2.6	2	Widening	21	Medium	
5.5	New Construction and Improvement of Road in the Machava Urban Area	12.1	2	Widening / new	13	Medium	
5.6	New Construction and Improvement of Road in the Matola Suburban Area	26.5	2	Widening	22	Medium	
5.8	KaTembe R403 Improvement	10.4	2	Paving	13	Medium	
6.1	Maputo Central Urban Area Peripheral Road Four-Lane Widening	4.3	4	4-lane	19	Medium	
6.2	Western Airport Area Route Improvement	7.1	2	Widening / paving/ new	26	Medium	
6.3	New Construction and Improvement of Greenbelt Road	6.3	2	New	13	Medium	
6.4	Matola Power Cable Line Extension New Road Construction	3.7	2	New	11	Medium	
7.3	Northern Infulene–Maputo Connection Road Improvement	6.6	2	Paving / widening	23	Medium	
8.1	Costa do Sol Area Road Network New Construction for District Development	11.8	2	New	28	Medium	
Improvement for BRT							
9.4	BRT Maputo Machava East-west Line	10.4	BRT+4	Paving / widening	N/A	Medium	No.2.3
9.5	BRT Maputo Matola Sede Line	14.0	BRT+4 (6)	Paving / new	N/A	Medium	
9.6	BRT Matola N4 Line (South)	7.9	BRT+4	Paving	N/A	Medium	
9.7	BRT Inner Ring Road Line	19.3	BRT+4	Paving / new	N/A	Medium	No.2.2

Source: JICA Project Team



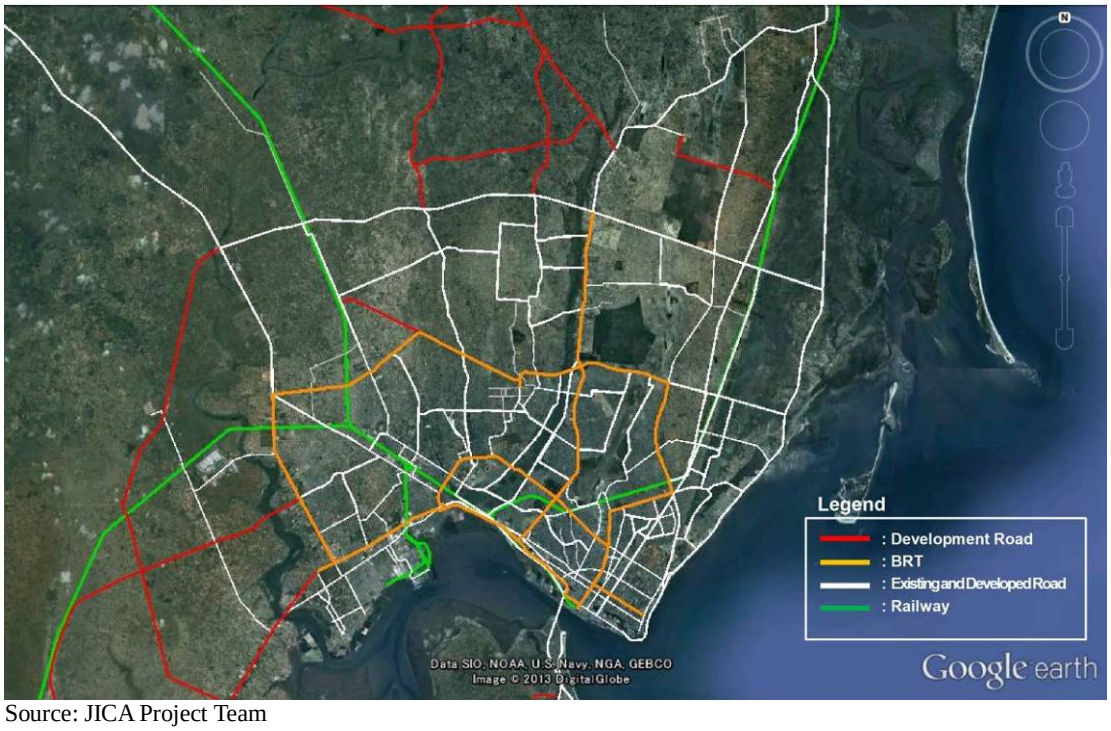
Source: JICA Project Team

Figure 7.10: Road Network in 2025

Table 7.10: Phasing of Road Network Development for 2035

No.	Project Component	Length (km)	Number of Lanes	Project Type	Ranking based on Scoring	Proposed Term	Remarks
2.4	Boane Outer Ring Road New Construction and N2 Widening	30.6	4	New / 4-lane	29	Long	
8.2	Northern Matola Area New Road Construction for District Development	51.5	2	Widening /new / paving	32	Long	
8.3	Marracuene East-West Route New Construction	5.3	2	New	26	Long	
8.4	Boane Connection New Road Construction for District Development	19.6	2	New	31	Long	
8.5	Boane-KaTembe Connection New Road Construction for District Development	25.7	2	New	29	Long	

Source: JICA Project Team



Source: JICA Project Team

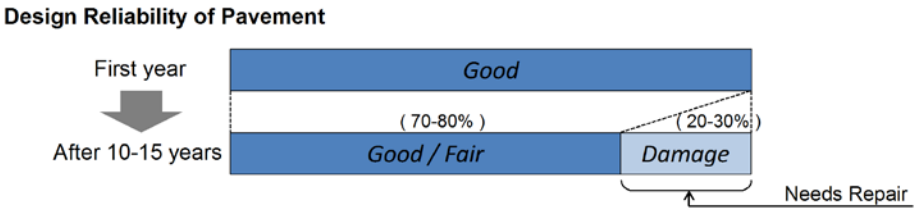
Figure 7.11: Road Network in 2035

7.3.4 Introduction of a Better Road Maintenance System

Poor road surface conditions and urban flooding are mainly due to the inadequacy of the maintenance system, capacity, and budget. The road maintenance system should be improved to achieve and maintain sustainable road traffic conditions. The road maintenance policies should include: (i) achieving a stable level of road maintenance, (ii) strengthening the road disaster prevention system, and (iii) extending the lifetime of road infrastructure.

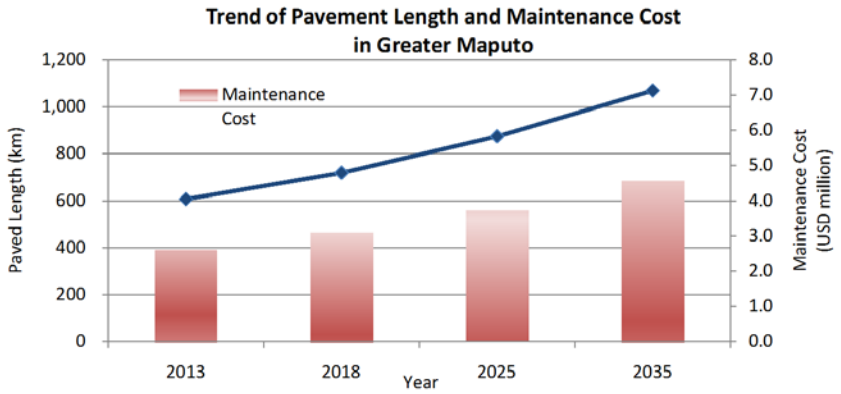
(1) Extending Road Length and Maintenance

After roads have been constructed and extended, an appropriate maintenance system is necessary to maintain its functions. It is possible to elongate the operating life of roads and reduce the total maintenance cost by having an appropriate maintenance system. There is routine maintenance and regular maintenance for roads, and this maintenance level should be determined based on the actual road condition. If there is partial damage to the pavement, this damage will not only reduce its service life but can also result in the incurrence of social costs due to diminishing service levels and traffic accidents. Therefore, an efficient maintenance system and sufficient budget are required for adequate road maintenance. Design reliability of pavement and pavement length/maintenance cost in Greater Maputo are shown in Figure 7.12 and Figure 7.13.



Source: ANE's Design Standards and JICA Project Team

Figure 7.12: Design Reliability of Pavement



Source: JICA Project Team

Figure 7.13: Pavement Length and Maintenance Cost

(2) Road Maintenance Capacity Strengthening Project

An appropriate maintenance system is important in keeping roads in a functional state. A project to strengthen road maintenance capacity to allow for effective maintenance of roads based on actual road conditions is recommended. An outline of such a project follows.

Overall Goal

- To effectively utilize the road budget by improving maintenance capacity.

Project Purpose

- Routine, regular, and urgent maintenance, as well as road management in the case of disasters and accidents, are to be properly carried out by the infrastructure department in Greater Maputo.

Outputs

- Establishment of a management and maintenance system for roads in Greater Maputo.
- Achievement of a secure road maintenance budget, to be invested prudently.
- Improvement in the knowledge and technical capabilities of the infrastructure department regarding road infrastructure.

Target Area

- Road network in Greater Maputo (except for roads managed by ANE)

Implementing Organizations

- Maputo Municipal Infrastructure Department
- Matola Municipal Infrastructure Department
- Marracuene District Service Planning and Infrastructure Management Department
- Boane City Service Planning and Infrastructure Management Department

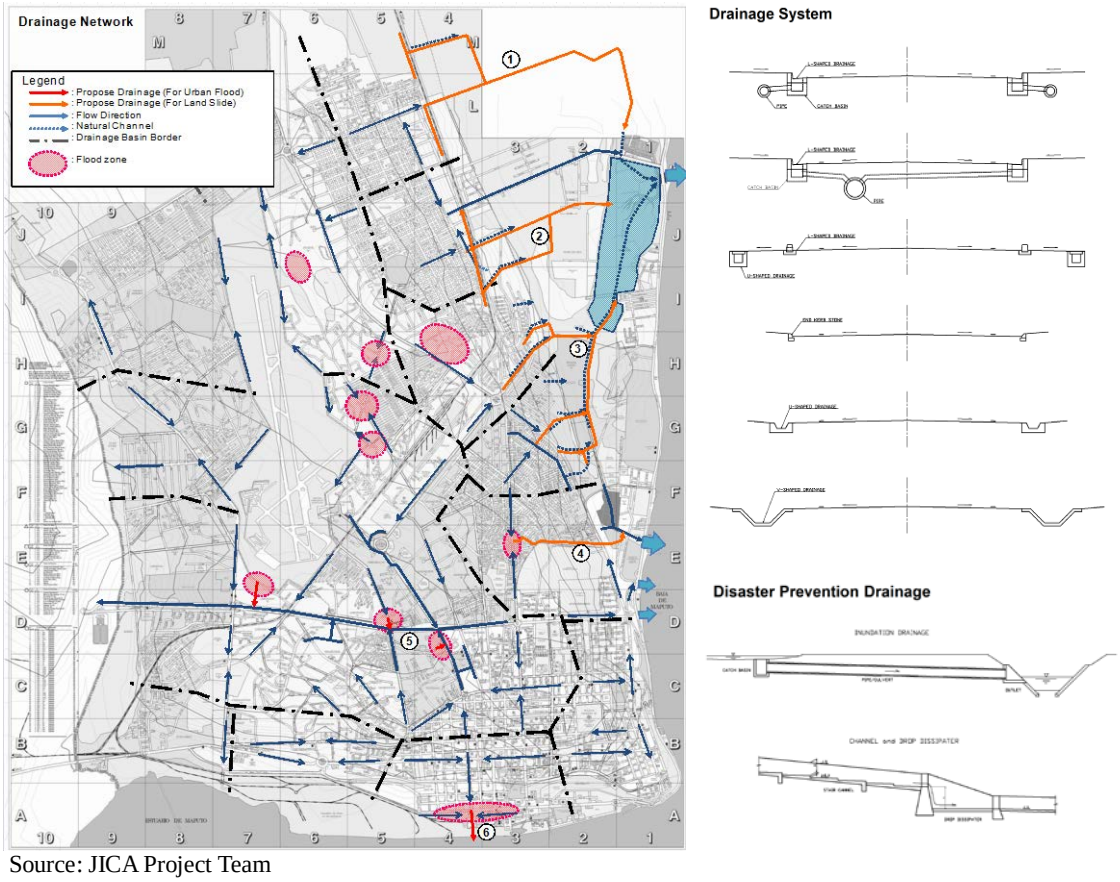
7.3.5 Drainage System

(1) Road Drainage

Various places in the Maputo urban area suffer damage from floods during the rainy season every year. Floods have had large social impacts such as blocking roads and inundating residences. When a road is constructed, road drainage facilities should be constructed at the same time to promote traffic safety and prevent natural disasters. Such facilities must lead downstream following the area's topography, and the dimensions of drainage facilities should be established based on the conditions of the rainfall and topography in various places. Important functions of road drainage systems in urban areas include the following.

- Assuring vehicle operation and traffic safety during heavy rainfall
- Improving pavement durability (i.e., the stability of the subgrade and base course, and reinforcement of the roadside)
- Preventing natural disasters (e.g., flooding, erosion, landslides)

Figure 7.14 and Table 7.11 presents the existing drainage systems and proposes a new network.



Source: JICA Project Team

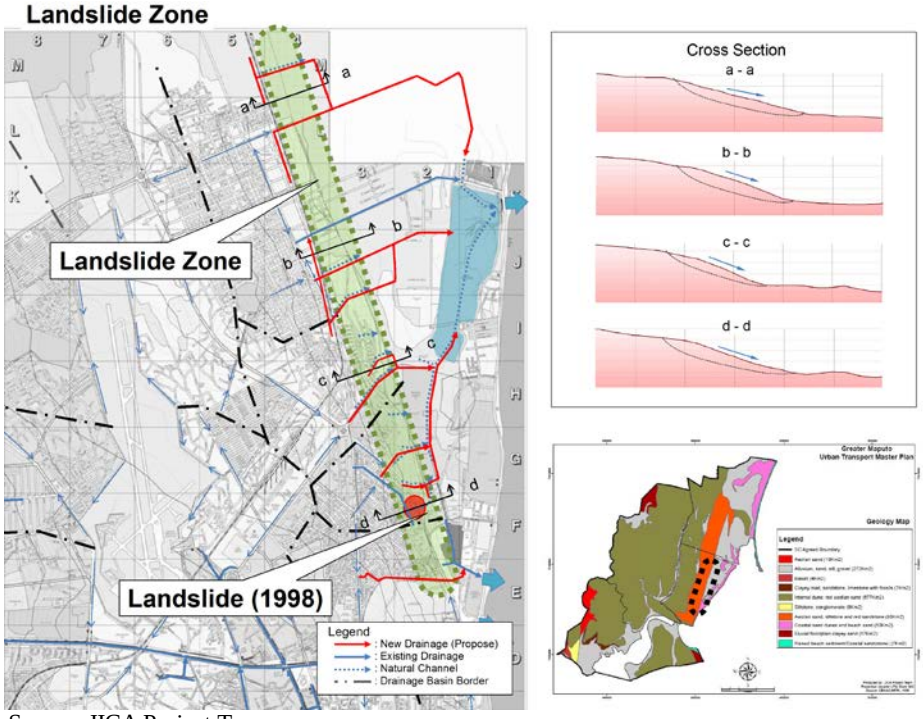
Figure 7.14: Existing Drainage System and Proposed New Network

Table 7.11: Proposed Drainage System

No.	Name	Main Facilities	Length (km)	Remark
1	Albasine Water-channel	Channel Drop-dissipater	6.6	Prevention of landslide and erosion
2	Ferroviário Water-channel	Channel Drop-dissipater	3.9	Prevention of landslide and erosion
3	Polana Caniço Water-channel	Channel Drop-dissipater	6.4	Prevention of landslide and erosion
4	Polana Caniço Water-channel	Channel Drop-dissipater	1.8	Prevention of landslide and erosion
5	Southern Airport Area Drainage	Pipe Catchment	0.5	Inundation prevention
6	Av. 25 de Setembro Drainage	Culvert Catchment	0.5	Inundation prevention

(2) Construction of Drainage Works for Landslide Prevention

Areas in eastern Maputo have experienced continuous and frequent landslides similar to what happened on Av. Julius Nyerere in 1998, due to their similar topography and geology. Erosion has been confirmed on sloping terrain, as shown in Figure 7.15. In addition, an increased outflow is expected due to rapid urbanization, and it is surmised that damage will amount to 100 or more households if a landslide such as the one in 1998 occurs, since it is a high density population area. Therefore, drainage works should be constructed to prevent landslides. Specific considerations include: (i) prevention of the penetration of rainwater underground (i.e., integration of drainage, induction to a lower stream); and (ii) prevention of erosion on slopes (i.e., flow channels, "drop dissipaters", flow-velocity control).



Source: JICA Project Team

Figure 7.15: Landslide Zones

(3) Greenbelt Floodway Development

A greenbelt should be utilized as a retarding basin (a basin designed and operated to provide temporary storage and thus reduce the peak flood flows of a stream) during floods. However, the riverbed slope is as flat as about 0.1% at the downstream site and the size of the river cross-section is insufficient at the intersection of N4 and the railway. When heavy rains result in flooding, transport networks are at great risk (e.g., road closures may occur). Therefore, downstream of the greenbelt floodways should be developed (e.g., at the site of the bridge at the intersection of N4 and the railway).

(4) Drainage System Technical Cooperation Project

A technical cooperation project to improve the drainage system for urban flood measures, disaster prevention, and maintenance is recommended. An outline of such a technical cooperation project follows.

Overall Goal

- To mitigate disasters such as floods in urban areas

Project Purpose

- Effective construction of required drainage facilities
- Proper maintenance of existing drainage facilities

Outputs

- Planning of an appropriate drainage system based on the topography and geology
- Production of a map of hazards
- Preparation of a drainage development plan
- Deliberate investment in drainage maintenance
- Improvement of knowledge and technological capability about drainage facilities

Target Area

- Maputo and Matola Urban Area

Implementing Organizations

- Maputo Municipal Infrastructure Department
- Matola Municipal Infrastructure Department

7.4 Summary

A road classification scheme was prepared for the road network development strategy. In addition, a long list of projects for the road network focusing on the development of the major arterial road network in Greater Maputo and arterial roads in each district, was prepared in order to select a candidate project. In the road network plan, the cross-section was specified based on ANE design standards. Furthermore, a target pavement ratio was proposed as an evaluation index. Optional projects were also prepared, including a road maintenance capacity strengthening project and a drainage system technical cooperation project.

Important projects that should be developed with priority are identified using a multi-criterion analysis from a long list of proposed road network projects. In addition, short-term road projects which can be immediately carried out (e.g. paving) with limited scope and low cost, were also selected.